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A
TREATISE
Containing the
ELEMENTARY PART
OF
FORTIFICATION,
Regular and Irregular.

With REMARKS on the Constructions of the most celebrated Authors, particularly of Marshal de VAUBAN and Baron COEHORN, in which the Perfection and Imperfection of their several Works are considered.

For the USE of the

Royal Academy of ARTILLERY at *Woolwich*.

Illustrated with Thirty-four Copper Plates.

By *JOHN MULLER*, Professor of Artillery and Fortification. k

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MDCCXLVI.

To his GRACE,

JOHN

Duke of MONTAGU, &c.

One of his Majesty's most honourable Privy-council, Great Master of the most honourable order of the Bath, *Knight of the most noble order of the Garter, Master of the King's great wardrobe, Colonel of the Queen's royal regiment of horse, and Master-general of the ordnance,* &c.

May it please your Grace,

THE institution of the royal academy for the instruction of military gentlemen, will be a lasting monument of your Grace's attention to his Majesty's service and of your encouragement of useful learning.

As your Grace has been pleased to appoint me to instruct the young gentlemen of the academy, and this work having been compiled for their improvement, it naturally claims your Grace's patronage; which, if I am so happy to obtain, will gratify the utmost of my wishes, as I have thereby an opportunity of assuring your Grace of the sense I have of your goodness and generosity, and of the gratitude with which I am most respectfully,

Your Grace's

most obedient

and most devoted

humble servant,

From the Royal Academy at *Woolwich*, *August* 27th, 1746.

John Muller.

THE

PREFACE.

SINCE the invention of gunpowder, fortification has received various improvements, and many have been the books wrote upon this ſubject, which might incline one to think, that it was arrived to its utmoſt perfection; but upon an impartial ſurvey of moſt of the writers, it will be found, if I miſtake not, that many of them are deficient either in theory or practice, and others blinded by prejudice, ſo that there is much room left to exerciſe the genius and excite the induſtry of thoſe whoſe buſineſs leads them to this ſtudy; beſides, as the art of attacking received ſeveral improvements in the late wars, it ſhould follow that the art of fortifying requires likewiſe improvements in proportion.

Not a few authors have proceeded upon maxims, ſome of which are uncertain, others trifling, and they have often neglected thoſe which are ſelf-evident; this together with their adopting ſome favourite ſcheme has retarded its progreſs.

Particular care ſhould be taken, in tracing plans on paper, to know whether they are practicable or not; which has been neglected by many, even by ſome of thoſe who are generally eſteemed the beſt writers.

Some think it ſufficient, that they make ſchemes, with a great many outworks upon outworks, ſo as theſe works defend each other; without conſidering whether the town thus ſurrounded is ſpacious enough to hold, beſides the inhabitants, a gariſon ſufficient to defend it: or the expence it would require to maintain them, and likewiſe the neceſſary ſtores: it is true they never fail to tell you that they have ſome ſecret, which enables them to build for half the coſt that others do.

Notwithſtanding the art of fortifying irregular places is moſt uſeful, yet no author whom I know has given the leaſt hint or direction whereby to judge of the advantage or diſadvantage of the ſeveral parts of ſuch a place: all they do conſiſts in giving ſome ſchemes of their own fancy, and telling us no work ought to be made without being defended by ſome other; not conſidering, that although the parts defend each other, there may be ſome which are much ſtronger than others.

For

For the true art consists in making an irregular fortification every where equally strong, which they seemed to be ignorant of, or if they knew it, they could not distinguish the strong from the weak.

The commentators on M. *Vauban*'s methods, who are so lavish in his praises, do not mention any thing of his way of fortifying irregular places; although he understood it better than any one, as appears by a great many examples of this kind; neither has any of them shewn why he made always the exterior side next to a river much longer than any other, as may be be seen in the plans of *Hunningen* and *Sarrelouis*; yet it is unquestionable that a man of so much experience had some very good reasons for what he did.

The very same mistake is made with regard to M. *Coehorn*, by those who praise him to the skies, on account of his treatise which he published before he had acquired that great experience, for which he was so justly esteemed in his latter years; and it is an undoubted proof that he himself was of the same opinion afterwards, since he did not use any of the methods published in his book, when he fortified *Bergen-op-zoom* and part of

Manheim: had he left us in writing that knowledge which he acquired by his great experience, it would have undoubtedly been worthy of ſo great a man, and would have perfectly juſtified the high opinion the world conceived of him.

It will not be improper to mention *Daniel Specle*, who publiſhed a book of fortification in the year 1589 at *Straſbourg* in the *German* language, which M. *Coehorn* has chiefly followed, as may be ſeen by comparing their works; and *Dilichius*, who publiſhed his *Hiperbologia* in the year 1640, at *Franckfurt* on the *Main* in *German* and *Latin*, was followed by M. *Vauban*; ſince there is nothing in this author, beſides his concave flanks, but what is to be found in the other.

Theſe two *German* authors were undoubtedly the beſt in their times, and as it were the fountains from which the preſent methods are derived: the few improvements made ſince are ſufficient proofs of their ſkill, and at the ſame time of the barrenneſs of invention of thoſe ſince.

As M. *Vauban*'s methods are now moſt in vogue, and chiefly uſed all over *Europe*; we thought it would not be improper to explain

plain them first, and after his, those of M. *Coehorn*, which are next in esteem; and then lay down some principles, whereby the advantage or disadvantage of a fortification may be known; after this, we have examined their methods in each part separately, and pointed out their several deficiencies, and afterwards have given some of the same works with proper corrections.

Then we propose three different methods, which we hope are not altogether to be despised, and which we think might be used according to the different situations and importance of places: this with the constructions of some of the most celebrated authors, and their examination, finishes the regular part of fortification.

We begin the irregular, by shewing how a place that cannot be made regular, may be made so as one half may be similar and equal to the other half; then we inquire which part of such a fortification is strongest and which is weakest; these principles, which are demonstrable, serve to judge of the weakest and strongest part of any irregular fortification whatsoever; and for a farther confirmation of the truth of them, we refer the reader to several places in *Flanders* fortified by the greatest

greateſt maſters, and which agree exactly with what we have advanced.

As the greateſt ſtrength of this and all maritime nations, conſiſts in traffic, and as fortified places which lie near rivers, lakes, creeks, or the ſea, chiefly ſerve to protect and promote trade, we have dwelled upon and explained their conſtructions in a more particular manner, and nothing has been omitted that could be thought of, which might any ways contribute to the right underſtanding this ſubject.

Several examples are given, in order to ſhew, how and in what manner the reader may proceed, if he finds himſelf employed in the conſtruction of ſuch places; the ſeveral advantages and diſadvantages of their ſituations are carefully examined, and thoſe which require leaſt expence to fortify, and are moſt convenient in other reſpects, are diſtinguiſhed; for a further explanation we have examined ſeveral ſea-port towns, and pointed out thoſe which deſerve to be imitated, and others, which ſhould be avoided, the plan of *Toulon* with its harbour is inſerted, as being one of the beſt in *Europe*: laſtly, we have given the principal conditions required in the conſtruction of ſuch places.

Having

Having thus far explained the ſeveral parts of irregular fortification, we proceed to ſhew how citadels are to be joined to places and the faults committed in ſome of the fineſt in *Europe* are pointed out; the work concludes with the manner of building forts, where particular notice has been taken of the methods generally followed in the building of ſuch works, near rivers and the ſea, and ſhewn their ill conſequences; as this ſubject is very important to this nation on account of the many forts we have and daily build, ſo we have endeavoured to point out the moſt proper manner, in which they ſhould be made.

The preſent undertaking contains the theoretical part of fortification only, we reſerve the practical one for another volume, where every part ſhall be fully and particularly explained. We ſhall finiſh by begging the reader's indulgence, in regard to the language, which we could not promiſe ourſelves to write with the purity of an *Engliſhman* born.

THE

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A

TREATISE

CONTAINING

The Elementary PART

OF

FORTIFICATION.

SECT. I.

Of practical Geometry.

DEFINITIONS.

1. EXTENSION is distinguished into *length*, *breadth*, and *thickness*, which are called *dimensions*. Plate A.

2. A *line* has only length, as AB.

3. The terms or bounds of a line are called *points*, and have no dimensions.

4. A *surface* has length and breadth only, as C.

The bounds of a surface are lines.

5. A *ſolid* has length, breadth, and thickneſs, as D.

The bounds of a ſolid are ſurfaces.

6. A *right-line* is the ſhorteſt that can be drawn from one point to another.

7. *Parallel lines* are thoſe which are every where equidiſtant, although produced ad infinitum, as AB, CD.

8. A *plane ſurface* is that which lies evenly between its bounds, and agrees with a right line placed on it according to any poſition.

2. The opening of two lines, which meet each other in a point, is called an *angle*, as A.

N. B. An angle is generally expreſſed by three letters as BCD, with the letter expreſſing the angular point in the middle.

10. If a line CD meets another line AB, ſo that the angles CDA, CDB, are equal; that line CD, is ſaid to be *perpendicular* to the other AB.

And the equal angles CDA, CDB, are called *right angles*.

But if the line is oblique as DE, the greateſt angle EDA, is called an *obtuſe* angle; and the leaſt EDB, an *acute* angle

11. A plane surface terminated by three right lines, is called a *plain triangle.*

12. When the three sides of a triangle are equal, it is called an *equilateral triangle*, as C.

13. When only two sides are equal, an *isosceles triangle*, as A.

14. When the three sides are unequal, a *scalene triangle*, as B.

15. When one angle of a triangle is a right angle, it is called a *right angled* triangle, as D.

16. Any one side of a triangle may be called the *base*, and the angular point opposite to the base, is called the *vertex.*

17. In a right angled triangle, the side opposite to the right angle, is called the *hypothenuse.*

18. A plane of four sides, is called in general a *quadrilateral* figure.

19. A quadrilateral, whose four sides are equal as well as the four angles, is called a *square*, as A.

20. If the four angles are equal, and only the opposite sides a *rectangle*, as B.

21. If the opposite angles are only equal, and the opposite sides, a *parallelogram*, as C.

22. A plane figure of above four sides, is called in general a *polygon.*

23. A *circle* is a plane figure bounded by one continued line ABC called the *circumference*, which is every where equally distant from a point O within the circle, called the *center*.

24. Any line, as A O, drawn from the center to the circumference, is called a *radius*.

25. Any line, as A B, terminating in a circle, is called a *chord*, which divides the circle into two parts, ACB, ADB, called *segments*, the parts of the circumference, terminated by the chord, are called *arcs*, and when the chord passes through the center it is called a *diameter*, and divides the circle into two equal parts, called *semi-circles*.

26. Any part of the circle, as AOB, terminated by two radii and an arc, is called a *sector*.

27. The measure of an angle, is the arc described from the angular point as center with any radius, and terminated by the lines which form the angle.

28. A line AT, which touches a circle in one point A only, is called a *tangent*; and the point A, where it touches, the point of *contact*.

29. The line CT drawn from the center and terminated by the tangent, is called the *secant*

ſecant of the arc AM, as AT is called its *tangent*, and the perpendicular PM to the radius CA the *ſine*, CP the *coſine*, and AP the *verſed ſine* of that arc, or of the arc BM, its ſupplement to a ſemi-circle.

30. A polygon is called *regular*, when all its ſides are equal as well as all its angles; and *irregular* when they are unequal.

31. A polygon is ſaid to be *inſcribed* in a circle when all its angles touch the circumference, and *circumſcribed* about a circle, when all its ſides touch the circle.

Polygons are diſtinguiſhed by the number of their ſides, viz.

5	Pentagon.	9	Enneagon.
6	Exagon.	10	Decagon.
7	Eptagon.	11	Ondecagon.
8	Octagon.	12	Dodecagon.

Problems uſeful in Fortification.

1. *To draw a line, through a given point* C, *perpendicular to another line* AB.

From the given point C as center, deſcribe an arc with any radius ſo as to meet the line AB, in two points E, F, and from theſe points as centers deſcribe two arcs with the ſame

radius, ſo as to interſect each other at D; then the line drawn through this interſection and the given point C will be the perpendicular required.

2. *To draw a line, through a given point* C, *parallel to another line* AB.

From the given point C as center, deſcribe an arc ſo as to touch the line AB, and from any point E in AB as center, deſcribe another arc with the ſame radius; then the line drawn through the given point C, ſo as to touch this arc, will be the parallel required.

3. *To divide a given line* AB, *into any number of equal parts, as five.*

Through the extremity A, draw a line AC at pleaſure ſo as to make any angle with AB, and through the other extremity B, draw BD parallel to AC: then if from the point A towards C, there be ſet off as many equal parts leſs one of any length, on AC, as the line AB is to be divided into, and the ſame thing be done on the line BD; the lines which join the oppoſite points, will divide the line AB into the deſired number of equal parts.

4. *To divide a given angle* ACB *into two equal parts.*

From

From the angular point C as center, deſcribe an arc with any radius, meeting the legs of the angle at A, B: from theſe points as centers deſcribe two arcs with the ſame radius, ſo as to interſect each other at D; then the line drawn through this interſection and the angular point C, will biſect the given angle.

5. *To draw a line* CA, *ſo as to make an angle* ACB *with a given line* CB, *equal to a given angle* acb.

From the points C, c, as centers, deſcribe two arcs with the ſame radius taken at pleaſure: make the arc AB equal to the arc ab; and the line drawn through the points C, A, will make the angle required.

N. B. Mathematicians ſuppoſe the circumference of a circle to be divided into 360 equal parts called degrees, each degree divided into 60 equal parts called minutes, as likewiſe each minute into 60 equal parts called ſeconds.

Theſe diviſions are generally marked on a braſs ſemi-circle or a rectangular piece of ivory, called protractor, and ſerve either to meaſure any angle by, or to lay down any angle on paper.

Hence a quadrant or the meaſures of a right angle is 90 degrees, as being the fourth

part of the circumference; a ſemi-circle or the meaſure of two right angles 180; and becauſe the three angles of a triangle being equal to two right ones; each of the angles of an equilateral triangle, is one third of 180; that is 60 degrees, or the ſixth part of the whole circumference.

6. *To biſect a line* AB, *by a perpendicular to it.*

From the extremities A, B, as centers, deſcribe arcs on both ſides of that line, with any radius ſo as to interſect each other at D, and E; then the line DF will be perpendicular to and biſect AB.

7. *To deſcribe the circumference of a circle, through three given points* A, B, C.

Join theſe points by two lines AB, BC; biſect theſe lines by the perpendiculars DO, EO; then their interſection O, will be the center of the circle deſired.

8. *To inſcribe a ſquare in a circle.*

Draw the diameter AB, to which draw the diameter CD perpendicular; then the lines joining the extremities of theſe diameters will be the ſquare ABCD required.

If the quadrant AC be biſected in E, the chord AE or EC will be the ſide of an octagon, inſcribed in the circle.

9. *To*

9. *To inſcribe a pentagon or a decagon in a circle.*

Draw the radius DC at right angles to the diameter AB, biſect AC in E, and from the point E as center, deſcribe an arc through the point D meeting the diameter AB in F, draw DF; then will DF be the ſide of the pentagon, and CF that of the decagon inſcribed in the circle.

10. *To inſcribe an exagon in a circle.*

Take the radius AO and carry it round the circumference, and you will have the exagon required.

If the arc AB be biſected at D, the chord of the arc AD or DB, will be the ſide of a dodecagon inſcribed in the circle.

N. B. The eptagon, enneagon, and ondecagon, cannot be geometrically inſcribed in a circle; for which reaſon we ſhall give mechanical conſtructions of them, which are ſufficiently exact for practice.

11. *To inſcribe an eptagon in a circle.*

From any point A in the circumference as center, deſcribe an arc through the center O, meeting the circumference in B and C; draw CB and the radius AO; then the half BD or DC of BC will be the ſide of an eptagon nearly.

12. *To inſcribe an enneagon in a circle.*

Carry the radius from A to B, and divide the arc AB into three equal parts, by repeated trials; and let Aa be two thirds of AB; then the chord of Aa, will be the ſide of the enneagon exactly, if Aa is exactly two thirds of AB.

13. *To inſcribe an ondecagon in a circle.*

Draw the radius CD, perpendicular to the diameter AB; from the extremity B as center deſcribe an arc through the point D, meeting the diameter in E, at E erect a perpendicular EF, to the diameter, or draw EF parallel to CD, meeting the circumference in F; then if the arc AF be biſected in G, the chord of AG or GF will be the ſide of the ondecagon required.

14. *To inſcribe a polygon in a circle, ſo that its ſides ſhall be of a given length.*

Inſcribe a ſimilar polygon, that is one of the ſame number of ſides, in any circle by the foregoing problems; and let AB be one of thoſe ſides, which produce to C ſo as BC be equal to the given ſide, and draw CD parallel to the radius OB, till it meets the radius OA produced at D; then OD will be the radius of the circle required.

This

This problem is easier solved by means of a sector, in this manner. On the inner edge is a line marked polygon, whose numbers answer from a square or pentagon to a dodecagon; you take the length of the side of the polygon which is to be inscribed in a circle, between the points of your compass; and set one point upon the number of the sides on the sector, and open the sector so as the other point of the compass meets the same number on the other leg of the sector; then keeping the sector thus open, you take the opening from 6 to 6 on the sector between the points of your compass, and that will be the radius of the circle wanted.

DEFINITIONS.

The angle ABC made by any two contiguous sides of a polygon, is called the *angle of the polygon*; and the angle AOB made by two radii drawn to the extremities of the same side of a polygon, is called the *angle of the center*.

The angle of the center of a regular polygon is found, by dividing 360 degrees by the number of the sides: thus 360 divided by 5 gives 72 degrees for the angle of the center

center of a pentagon: and 360 divided by 6 gives 60 degrees for the angle of the center of an exagon.

But the angle of the polygon is found by ſubſtracting the angle of the center from 180 degrees; thus $180-72=108$ degrees in the pentagon; and $180-60=120$ degrees in the exagon.

Polygon.	Ang. Cent.	Ang. Polyg.
5	72	108
6	60	120
7	$51\frac{3}{7}$	$128\frac{4}{7}$
8	45	135
9	40	140
10	36	144
11	$32\frac{8}{11}$	$147\frac{3}{11}$
12	30	150

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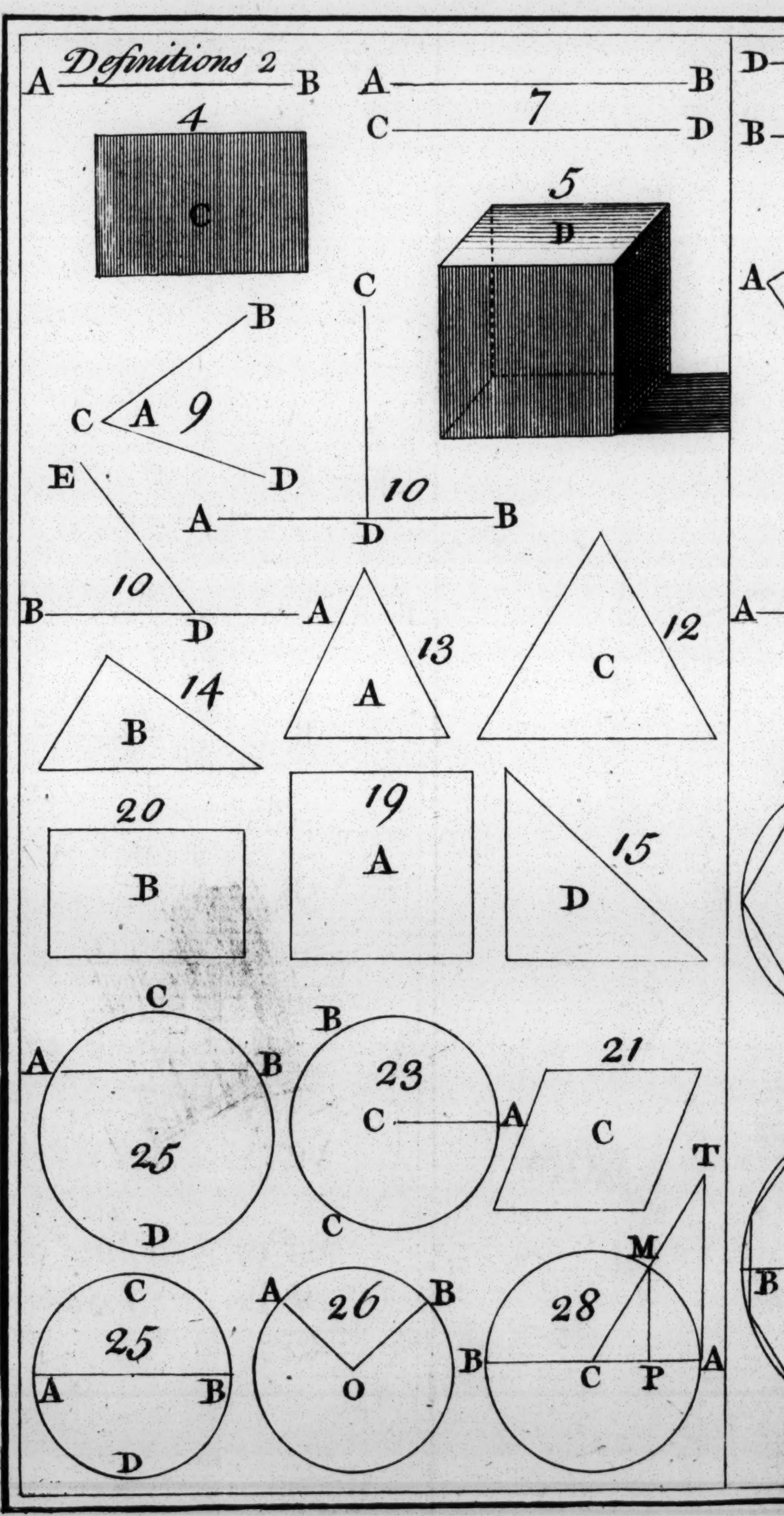
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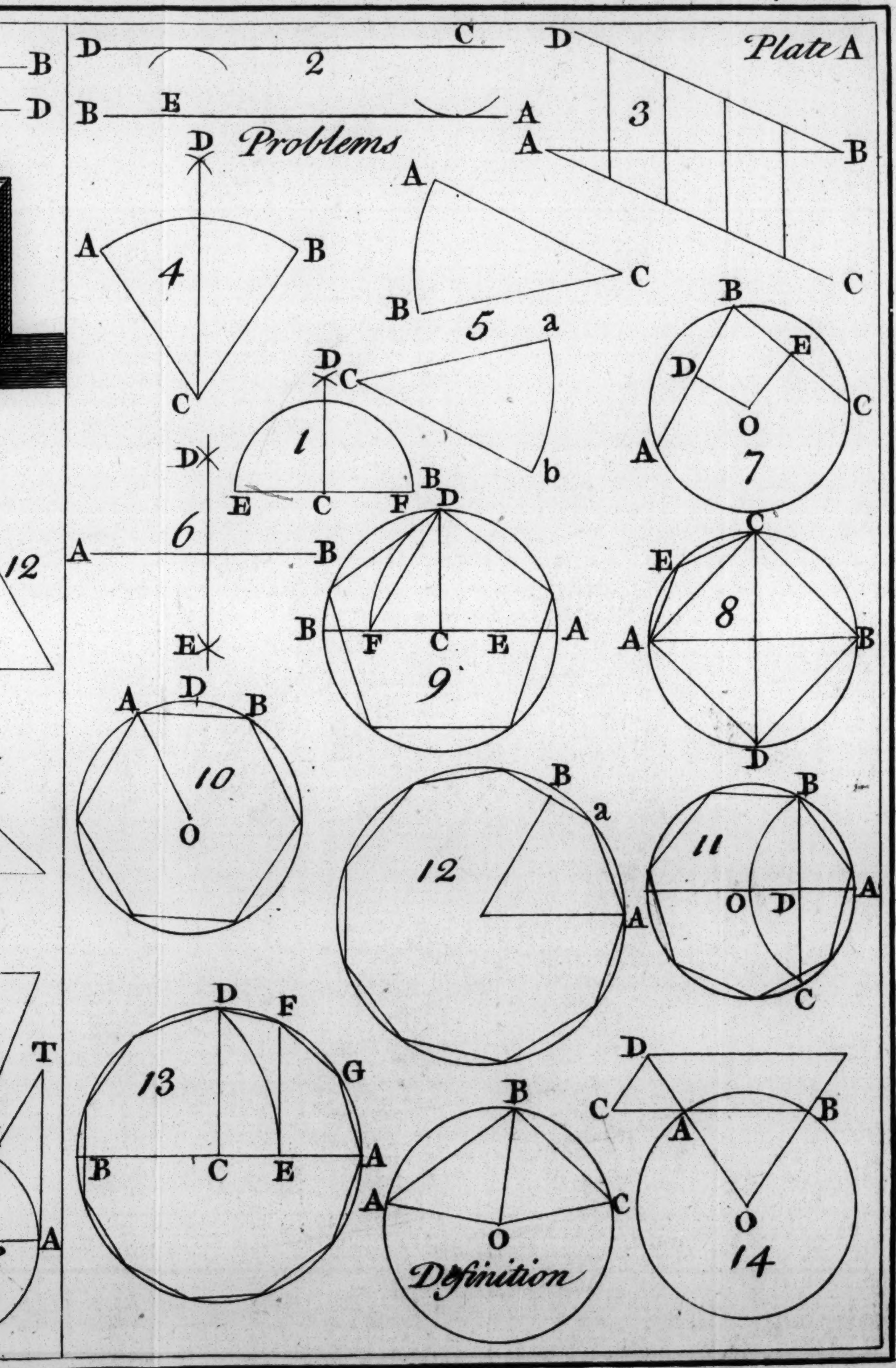

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Of the meaſures and ſcales uſed in Fortification.

The *French* make uſe of a meaſure called a *toiſe*, which is ſix feet, and therefore, is what we call a *fathom* here in *England*.

The *Dutch*, and moſt of the *Germans*, make uſe of the *Rhinland rod*, which is 12 Rhinland feet.

The *French* royal foot is to the *Engliſh* foot as 114 to 107, or as 16 to 15 nearly, in ſmaller numbers.

The Rhinland foot is to the *French* foot as 1033 to 1068, or as 29 to 30 nearly, in ſmaller numbers; and therefore, half the Rhinland rod is to a *French* toiſe as 29 to 30 nearly.

As we propoſe to give Mr. *Vauban*'s conſtructions, with thoſe of the moſt celebrated authors of that nation, we ſhall uſe the word toiſes in this work, as being more convenient for underſtanding their methods than that of fathom; the valuation of the *French* into *Engliſh* meaſure, may be eaſily made by the proportion given above.

When a plan of a fortification is to be drawn, which is to be executed, it will be con-

convenient to have a ſcale divided into equal parts, as for example, an inch divided into 20, 25, 30, 35, 40, 45, 50, 55, 60: then that of 40 to an inch is to be uſed in this caſe, in order to expreſs every part diſtinctly, which cannot ſo well be done upon a ſmaller one.

When a plan is to be drawn upon any other occaſion, any other ſcale will do, which may be greater or leſs, according as it is thought moſt convenient.

The profils are generally drawn upon a ſcale of 30 feet to an inch; becauſe they are to expreſs the heights of the different parts, which cannot ſo well be done upon a leſſer.

If a ſcale ready divided cannot be had, or ſuch a one as may be wanted upon a particular occaſion, there muſt be one made on ſtrong paper, by the help of the third problem.

Colours uſed in the drawings of Fortifications.

It is neceſſary to uſe colours in the drawings of plans and profils of a fortification, in order to diſtinguiſh every particular part, and ſepa-

ſeparate, as it were, the one from the other, ſo as to make their difference more ſenſible. The manner of uſing colours, is called *colouring*.

The firſt and moſt neceſſary thing required in drawing is, *Indian ink*; for it ſerves in drawing the lines, to expreſs hills or riſing grounds, and in ſhort, for all what is called ſhading in drawings.

There are ſix different ſorts of colours, generally uſed in theſe kind of drawings, viz. *carmine*, *verdegreaſe*, *ſap-green*, *gum-bouch*, *indigo* and *umber*.

The beſt ſort of Indian ink, is of a bluiſh black, ſoft and eaſily reduced into a liquid, free from ſand or gravel: it is ſolid in ſticks for three pence a ſtick to half a crown, according to its goodneſs and quantity.

The manner of liquifying it, is by putting a little clear water into a ſhell or tea-cup, and rubbing it gently till the water is black, and of a conſiſtence much like common ink; when it is uſed for drawing lines, it muſt be made very black, though not too thick, otherwiſe it will not eaſily flow out of the drawing pen: but when it is for ſhading, it muſt be pale, ſo as to go over the ſame ſhade ſeveral times, which will make it look much finer

ner and ſofter, than if it was done at once.

Carmine is in powder and the fineſt red we know of: it ſerves for colouring the ſections of maſonry; the plans of houſes, and other buildings, as likewiſe their elevations, but is then made of a paler colour.

This colour is alſo uſed for drawing red lines in plans, to repreſent walls: it is very dear, being generally a guinea an ounce, but a little goes a great way.

The verdegreaſe uſed in drawings, which is commonly called *ſea-green*, is liquid, and ſold in little viols for ſix-pence a piece; it ſerves to colour wet ditches, rivers, ſeas, and in general to repreſent all watry places.

Sap-green is in ſtone, of a yellowiſh green, when liquified with clear water; but when it is mixt with ſome ſea-green, it makes a fine graſs green; as all mixt colours are liable to fade, if *verd'iris* can be had, it will be much better; ſap-green is very cheap, for two or three pence, one may have as much as will ſerve a great while.

Gum-bouch, is a fine yellow in ſtones, and very cheap; it ſerves to colour all projects of works; as likewiſe to diſtinguiſh the works unfiniſhed from thoſe that are ſo. It ſerves alſo to colour the trenches of an attack.

This

This colour is prepared, by taking water in a hair pencil, and rubbing it gently, then putting it in a ſhell, and this is repeated till the colour is as ſtrong as is neceſſary.

Indigo is in ſmall cakes, and very cheap; it ſerves to colour iron and roofs of buildings, which are covered with ſlates: It muſt be well ground upon a ſmooth ſtone or glaſs, and then mixt with a little gum water.

If the ſeagreen is too pale, by mixing a little indigo with it, it will make a fine bluiſh colour.

Umber is a yellowiſh brown colour in powder; when it is mixt with gum water, it ſerves to colour dry ditches, ſand, and all things of earth. By mixing a little red ink with it, it will make alſo a wood colour. If ſome tobacco leaves are ſteept in clear water for ſome hours, and filtered through a woollen cloth, or brown paper, with a little red ink mixt in it, it makes the beſt earth or wood colour, as lying ſmoother than any other.

In drawing encampments, it is neceſſary to have a fine blue, to repreſent the colour of blue cloth; *ſmalt* ſold in ſhells for about a groat a piece is very good for that purpoſe, or elſe *Pruſſian blue*, well ground and mixt with a little gum water.

Gum water is beſt when it is made ſome time before it is uſed; for which reaſon, take ſome gum arabic, and ſteep it in clear water for ſome hours till it is diſſolved; then ſtrain it through a woollen cloth or brown paper, and preſerve it in a viol, well ſtopped, that no dirt can come into it, till it is wanted.

SECTION II.

Of regular Fortification.

FOrtification is the art of incloſing towns, with works in ſuch a manner, as that a ſmall number of men may reſiſt, for ſome time, a conſiderable army.

The attack of a place, is the art of making and conducting all the different works in a ſiege, in order to become maſter of the place.

And the defence of a place, is the art of defending a town beſieged, with all the advantages that the fortification will admit of.

The art of fortification may be diſtinguiſhed into two parts, *viz.* the elementary or theoretical, and practical.

This

The elementary part conſiſts in tracing the plans and profils of a fortification on paper, with ſcales and compaſſes; and to examine the ſyſtems propoſed by different authors, in order to diſcover their advantages and diſadvantages.

And the practical part conſiſts in forming a project of a fortification, according to the nature of the ground and other neceſſary circumſtances, to trace it on the ground, and to execute the project, together with all the military buildings, ſuch as magazines, ſtore-houſes, bridges, *&c.*

It is the elementary part which we propoſe to treat of in this work, reſerving the other for a ſecond volume, which we ſhall divide into regular and irregular fortification; but before we enter any farther upon the ſubject, it will not be diſagreeable to beginners to ſay ſomething concerning the riſe and progreſs of fortification.

The origin and riſe of fortification, is undoubtedly owing to the degeneracy of mankind; for in the firſt ages of the world, men were diſperſed up and down the countries in ſeparate families, as we are told in the hiſtories of the Jews and Scythians, who wandered from one place to another for the ſake of find-

ing paſture for their cattle. Theſe families became in time ſo numerous as to form large communities, which ſettled all together in a place; from whence villages and towns had their origin and riſe: but they found it was neceſſary, for the common ſecurity, to ſurround thoſe towns with walls and ditches, to prevent all violences *from their neighbours and ſudden ſurprizes.* This was ſufficient for ſome time, till offenſive weapons were invented, and conquering became a faſhion; then walls with loop-holes were made at proper diſtances, in order to ſcreen the defenders againſt the arrows of the aſſailants; but finding that as ſoon as the enemy got once cloſe to the walls, they could from no part be diſcovered or repulſed; for this reaſon they added ſquare towers at proper diſtances from each other, ſo that every part of the wall might be defended by the adjacent ſides of the towers. However this manner of incloſing of towns was found to be imperfect, becauſe there remained ſtill one of the faces of the towers which fronted the field that could not be ſeen from any other part, and therefore could not be defended. To remedy this, they made the towers round inſtead of ſquare, imagining this figure to be the ſtrongeſt to reſiſt

th

the battering engines, as likewiſe to be better defended from the other parts of the wall.

Notwithſtanding the ſuperiority of this method above the former, there remained yet a part of theſe towers unſeen and uncapable to be defended; which made them change the figure of the towers again; that is, they made them ſquares as before; but inſtead of preſenting a face to the field as formerly, they preſented an angle; by this means they effectually found out ſuch a diſpoſition of their works, that no part could be attacked without being ſeen or defended by ſome other part.

This laſt method was in uſe a long while, and would in all appearance have continued to this day, if gun-powder had not been found out: but the violence of the guns and mortars ſoon convinced the world, that ſuch towers and walls were but a weak defence againſt theſe thundering engines: and beſides, as the nature of the attack was entirely changed, it was alſo neceſſary to change that of fortifying likewiſe.

From that time, ramparts were added to the walls, the towers enlarged into baſtions, and all ſorts of outworks have been added, ſuch as ravelins, counterguards, horn and

crownworks, and others of the like nature, in order to render the defence in ſome meaſure equivalent to the attack.

Notwithſtanding all the improvements which have been made in the art of fortifying ſince the invention of gun-powder, that of attacking is ſtill ſuperior to it: Engineers have tried in vain to render the advantages of a fortification equal to thoſe of the attack; the ſuperiority of the beſiegers fire, together with the greater number of men, obliges generally, ſooner or later, the beſieged to ſubmit.

The greateſt improvement made in the art of attacking happened in the Year 1697, when M. Vauban made firſt uſe of ricochet firing at the ſiege of Ath, whereby the beſieged placed behind the parapets, were as much expoſed to the fire of the beſiegers as if there had been none; whereas before, they had been ſecure as long as the parapet was not demoliſhed: and the worſt is, that there can be no remedy found to prevent this enfilading without falling into inconveniencies almoſt as bad as thoſe which we endeavour to avoid.

Although authors agree as to the general form in the preſent manner of fortifying, yet they moſtly differ in particular conſtructions of the parts; as it would be both needleſs and ſuper-

ſuperfluous to treat of all the different methods hitherto propoſed, we ſhall content ourſelves with explaining thoſe only, which are moſt eſteemed by the beſt judges, and have been moſtly put in practice; with adding obſervations on their perfections and imperfections, and point out how ſome of the parts may be improved.

As M. Vauban had more experience than any other engineer whatſoever, and his methods are moſtly uſed all over Europe, we preſume it will be more advantageous to beginners to explain his methods firſt; and then thoſe of Mr. Coehorn, who, next to M. Vauban, excelled in this art.

M. Vauban has given three different methods, the firſt is that which has been uſed in the fortifying of moſt places; the ſecond was uſed at Landau and Beford, chiefly deſigned for places which have a wall or rampart already, and the third has been applied in the fortifying of New Briſach; each of theſe methods will be treated of ſeparately, in their order.

Construction of M. VAUBAN's *first Method.*

This method is divided into little, mean, and great; the little is chiefly used in the construction of citadels, the mean in that of all sorts of towns, and the great in particular cases only.

We shall give the construction of the mean, as being most useful, and refer the reader to the table hereafter, for those dimensions which are different in these several fortifications.

Plate I. Fig. 1. Inscribe in a circle a polygon of as many sides as the fortification is designed to have fronts; let AB be one of the sides of half an exagon, which bisect by the perpendicular CD: divide half AC of it, into nine equal parts, and one of these into ten others; then these divisions will serve as a scale to construct all the parts of the fortification, and each of them is supposed to be a toise or fathom, that is six French feet; and therefore the whole side AB is supposed to be 180 toises.

As the dividing a line into so many equal parts, is troublesome and tedious; it is more convenient to have a scale of equal parts by which the works may be constructed. If

If therefore, in this caſe, the radius is taken equal to 180 toiſes, and the circle deſcribed with that radius being divided into ſix equal parts, or the radius being carried ſix times round, you will have an exagon inſcribed; AB being biſected by the perpendicular CD as before, ſet off 30 toiſes from C to D, and draw the indefinite lines ADG, BDF, in which take the parts AE, BH each equal to 50 toiſes; from the center E deſcribe an arc through the point H, meeting AB in G, and from the center H deſcribe an arc through the point E, meeting BD in F; or which is the ſame, make each of the lines EG, HF equal to the diſtance EH; then the lines joining the points A, E, F, G, H, B, will be the principal or outline of the front.

If the ſame conſtruction be performed on the other ſides of the polygon, you will have the principal or outline of the whole fortification.

If, with a radius of 20 toiſes, there be deſcribed circular arcs, from the angular points B, A, M, T, and lines are drawn from the oppoſite angles E, H, &c. ſo as to touch theſe arcs, their parts ab, bc, &c. together with theſe arcs will repreſent the outline of the ditch.

De-

Definitions.

1. The part FEALN, is called the *bastion.*

2. AE, AL, the *faces* of the baſtion.

3. EF, LN, the *flanks.*

4. FG the *curtain.*

5. FN, the *gorge* of the baſtion.

6. AG, BF, the *lines of defence.*

7. AB, the *exterior ſide of the polygon.*

8. CD, the *perpendicular.*

9. Any line which divides a work into two equal parts, is called the *capital* of that work.

10. abc, the *counterſcarp* of the ditch.

11. A, M, the *flanked angles.*

12. H, E, L, the angles of the *ſhoulder* or *ſhoulder* only.

13. G, F, N, the *angles* of the *flank.*

14. Any angle whoſe point turns from the place is called a *ſaliant angle*, ſuch as A, M; and any angle whoſe point turns towards the place, *re-entring angle*, ſuch as b, F, N.

15. If there be drawn two lines parallel to the principal or outline, the one at 3 toiſes diſtance, and the other at 8 from it; then the ſpace yx included between the principal one, and that fartheſt diſtant, is called the *rampart.* And

And the ſpace xx, contained by the Principal line, and that next to it, and which is generally ſtained black, is called the *parapet*.

16. There is a fine line drawn within four feet of the parapet, which expreſſes a ſtep called *Banquette*.

N. B. All works have a parapet of three toiſes thick, and a rampart of 8 to 10, beſides their ſlopes. The rampart is elevated more or leſs above the level of the place, from 10 to 20 feet, according as the nature of the ground is, and according to the particular conſtructions of engineers.

The parapet is a part of the rampart elevated from 6 to $7\frac{1}{2}$ feet above the reſt, in order to cover the troops which are drawn up there, from the fire of the enemy in a ſiege; and the banquette is two or three feet higher than the rampart, or about four feet lower than the parapet; ſo that when the troops ſtand upon it, they may juſt be able to fire over the parapet.

17. The body of the place, is all that which is contained within this firſt rampart; for which reaſon, it is often ſaid to conſtruct the body of the place; which means properly, the conſtruction of the baſtions and curtains.

18.

18. All the works which are constructed beyond the ditch before the body of the place, are called *outworks*.

TABLE.

	Forts.						Little Fortif.				Mean		Great	
Side of Polyg.	80	90	100	110	120	130	140	150	160	170	180	190	200	260
Perpendicul.	10	11	12½	14	15	16	20	21	23	25	30	31	25	22
Faces bast.	22	25	28	30	33	35	40	42	45	47	50	53	55	60
Cap. of ravel.	25	28	30	35	38	40	45	50	50	52	55	55	60	50

In the first horizontal column are the numbers expressing the lengths of the exterior sides from 80 to 260.

In

In the ſecond, the perpendiculars anſwering to theſe ſides.

In the third, the lengths of the faces of the baſtions, and in the fourth, the lengths of the capitals of the ravelins.

The forts are moſtly, if not always, ſquares, for which reaſon, the perpendiculars are made one eighth of the exterior ſides; becauſe if they were more, the gorges of the baſtions would become too narrow.

The little fortification, is chiefly deſigned for citadels, and are commonly pentagons; the perpendiculars are made one ſeventh of the exterior ſide; the mean is uſed in all kinds of fortifications from an exagon upwards to any number of ſides: and the great is ſeldom uſed but in an irregular fortification, where there are ſome ſides that cannot be made leſs without much expence; or in a town which lies near a great river, where the ſide next the river is made from 200 to 260 toiſes; and as that ſide is leſs expoſed to be attacked than any other, the perpendicular is made ſhorter, which ſaves much expence.

The faces of the baſtions are all $\frac{2}{7}$ths of the exterior ſides, or nearly ſo, becauſe the fractions are neglected.

It

It may be obſerved in general, that in all ſquares the perpendicular is $\frac{1}{8}$th of the exterior ſide, in all pentagons $\frac{1}{7}$th, and in all the reſt upwards $\frac{1}{6}$th.

Conſtruction of Orillons and retired Flanks.

Deſcribe the front MPQRST as before, and divide the flank into three equal parts, of which ſuppoſe Sr to be one: from the oppoſite flanked angle M, draw a line Mr, in which take the part mr of 5 toiſes; take likewiſe Rn in the line of defence MR, produced, equal to 5 toiſes, and join nm, upon which as a baſe deſcribe the equilateral triangle npm, and from the angle p, oppoſite to the baſe as center, is deſcribed the circular flank nm.

And if Sr be biſected by the perpendicular 1, 2, and another be erected upon the face ST, at S; the interſection 2 of theſe two perpendiculars, will be the center of the arc which forms the orillon.

The orillons are very uſeful in covering the retired flanks, which cannot be ſeen but directly in the front; and as theſe orillons are round, they cannot be ſo eaſily deſtroyed as they

they would be, if they were of any other figure. But for what reaſon the retired flanks are made of ſuch circular arcs as theſe, is not poſſible to be gueſt at; ſince it may eaſily be proved, as we ſhall do in the third ſection, that the flank made upon the chord of that arc would be much better, and is at the ſame time of leſs expence.

But what is more ſtrange, that moſt engineers look upon theſe flanks as the beſt that could have been thought of; and they uſe them in all fortifications, which they propoſe as the beſt models: there can be given no other reaſon of this opinion, than the unaccountable fancy, of mankind in general, for novelty; and their indolence to receive from others, things for true, rather than to inquire whether they be ſo or not.

Conſtruction of Ravelins or Half-moons.

Set off 55 toiſes, from the re-entring angle O of the counterſcarp, on the capital OL, or on the perpendicular produced, and from the point L draw lines to the ſhoulders A, B; whoſe parts LM, LN, terminated by the counterſcarp will be the faces, and MO, ON the ſemi-gorges of the ravelin required. Fig. 2.

This

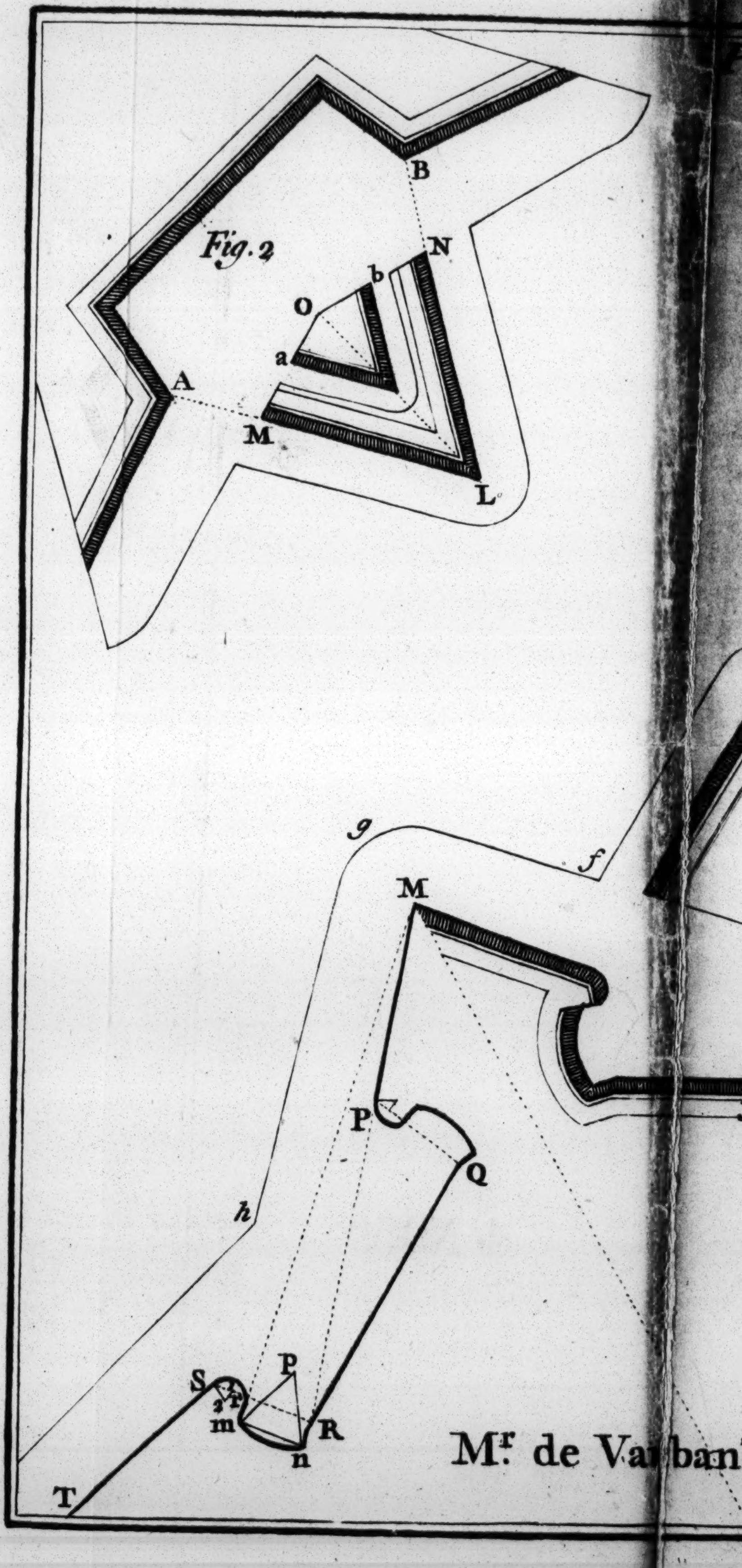
This is Mr. *Vauban*'s method of conſtructing ravelins, according to ſome authors; and others will have the faces of the ravelin to terminate on thoſe of the baſtions within 3 toiſes of the ſhoulders; which ſeems to be the beſt way, for the ravelins cover the flanks much better than the others.

The ditch before the ravelin is 12 toiſes, its counterſcarp parallel to the faces of the ravelins, and is made in a circular arc, before the ſaliant angle; as likewiſe all ditches are in general.

When the ravelins are made with flanks, as in figure 3, the faces ſhould terminate on thoſe of the baſtions, at leaſt 5 toiſes from the ſhoulders.

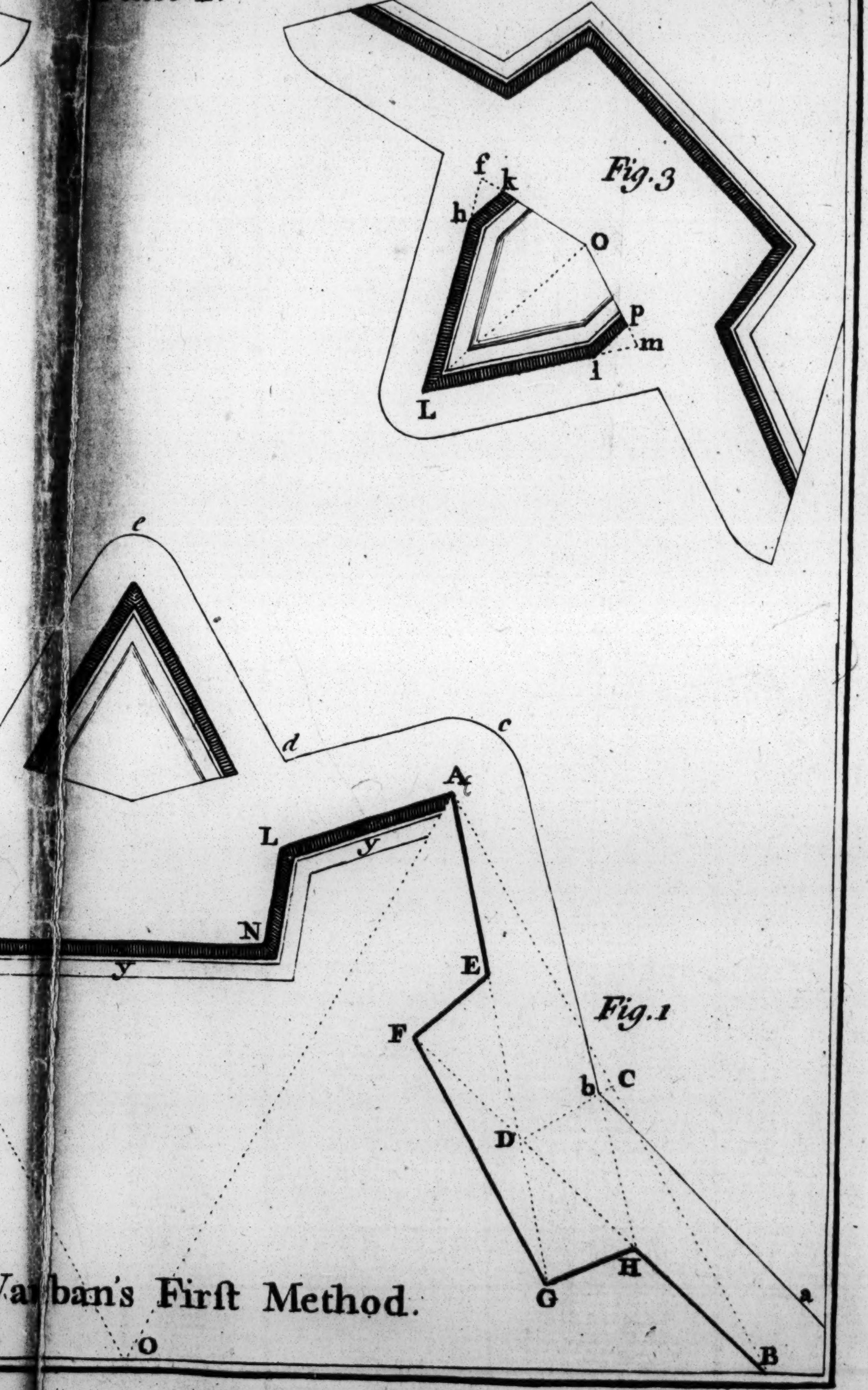
The flanks are made by ſetting off 10 toiſes from the extremities of the faces, from f to h, and from m to l, and from the points h, l, the flanks hk, lp, are drawn parallel to the capital LO of the ravelin.

There are ſometimes redouts made in the ravelin, ſuch as in fig. 2. which is done by ſetting off 16 toiſes from the extremities of the faces on the ſemi-gorges from N to b, and from M to a; and from the points b, a, the faces are drawn parallel to thoſe of the ravelin: the ditch before this redout is 6 toiſes, and its counterſcarp parallel to the faces. Con-



Mr. de Va ban

Plate I.



Vauban's First Method.

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Construction of Tenailles.

A tenaille is a work made in the ditch before the curtains, the parapet of which is only 2 or 3 feet higher than the level ground of the ravelin. There are three different sorts, the first are those as in fig. 1, which are made in the direction of the lines of defence, leaving a passage of 3 toises between their extremities and the flanks of the bastions, as likewise another of 2 in the middle for a bridge of communication to the ravelin. Plate II. fig. 1, 2, 3.

The second sort, are those as in fig. 2; their faces are in the lines of defences, and 16 toises long, besides the passage of 3 toises between them and the flanks of the bastions; their flanks are found by describing arcs from one shoulder of the tenaille as center thro' the other, on which are set off 10 toises for the flanks desired.

And the third sort, are those as in fig. 3; their faces are 16 toises, as in the second sort, and the flanks are parallel to those of the bastions.

The use in general of tenailles, is to defend the bottom of the ditch by a grazing fire, as likewise the level ground of the ravelin,

velin, and eſpecially the ditch before the redout within the ravelin, which can be defended from no where elſe, ſo well as from them.

The firſt ſort do not defend the ditch ſo well as the others, as being too oblique a defence; but as they are not ſubject to be enfiladed, M. *Vauban* has generally preferred them in the fortifying of places, as may be ſeen in the citadel of *Lille*, at *Landau*, *New-Briſach*, and in a great many other places.

The ſecond ſort defend the ditch much better than the firſt, and add a low flank to thoſe of the baſtions; but as theſe flanks are liable to be enfiladed, they have not been much put in practiſe. This defect might however be remedied, by making them ſo as to be covered by the extremities of the parapets of the oppoſite ravelins, or by ſome other work.

As to the third ſort, they have the ſame advantage as the ſecond, and are likewiſe liable to the ſame objections; for which reaſon they may be uſed with the ſame precautions, which have been mentioned in the ſecond.

Tenailles

Tenailles are esteemed so necessary, that there is hardly any place fortified without them, and it is not without reason; for when the ditch is dry, the part behind the tenailles serves as a place of arms, from which the troops may sally, destroy the works of the enemy in the ditch, oppose their descent, and retire with safety; and the communication from the body of the place to the ravelin, becomes easy and secure, which is a great advantage; for by that means the ravelin may make a much better defence, as it can be supplied with troops and necessaries at any time. And if the ditch is wet, they serve as harbours for boats, which may carry out armed men to oppose the passage over the ditch whenever they please; and the communication from the tenailles to the ravelin, becomes likewise much easier than it would be without them.

Construction of Lunettes.

Lunettes are placed on both sides of the ravelin, such as B, to encrease the strength of a place; they are constructed, by bisecting the faces of the ravelin with the perpendicular LN, on which is set off 30 toises from the coun- Fig. 4.

terſcarp of the ditch, for one of its faces; the other face PN, is found by making the ſemi-gorge TP of 25 toiſes; the ditch before the lunettes is 12 toiſes, the parapet 3, and the rampart 8; as in the ravelin.

There is ſometimes another work made to cover the ſaliant angle of the ravelin; ſuch as A, called *Bonnet*, whoſe faces are parallel to thoſe of the ravelin, and when produced biſect thoſe of the lunettes; the ditch before it is 10 toiſes.

Fig. 5. There are likewiſe lunettes, ſuch as D, in fig. 5, whoſe faces are drawn perpendicular to thoſe of the ravelin, within a third part from the ſaliant angle; and their ſemi-gorges are only 20 toiſes.

Theſe kind of works may make a good defence, and are no very great expence; for as they are ſo near the ravelin, the communication with it is very eaſy, and one cannot well be maintained, till they are all three taken.

I would have the face PN (fig. B) perpendicular to that of the baſtion, which would then defend it in a direct manner; and if the ſemi-gorges of the bonnet A were only 7 or 8 toiſes, it would become leſs expenſive, and its ditch and the covert-way before it would be better defended by the lunettes.

Con-

Construction of Tenaillons.

Produce the faces of the ravelin beyond the counterscarp of the ditch, at a distance MN of 30 toises, and take on the counterscarp of the great ditch, 15 toises from the re-entring angle p to q, and draw N q; then q N M p will be the tenaillon required; its ditch is 12 toises, that is, the same as that of the ravelin. Sometimes there is made a retired battery, in the front of the tenaillons, as in fig. B; this battery is 10 toises from the front to which it is parallel, and 15 toises long. Fig. 6.

There are commonly retrenchments made in the tenaillons, such as O; their parapets are parallel to the fronts MN, and bisect the side q N; the ditch before this retrenchment is 3 toises, and there is a banquette before the parapet, next to the ditch of about 8 feet, called *Berm*; it serves to prevent the earth of the parapet (which seldom has any revetement) from falling into the ditch.

It is to be observed, that the ravelin, before which tenaillons are constructed, must have its saliant angle much greater than the former construction makes them; otherwise the

the ſaliant angles of the tenaillons become too acute, for which reaſon we made the capital of this ravelin 45 toiſes, and the faces terminate within 3 toiſes of the ſhoulders.

Conſtruction of Counterguards.

Plate III. fig. 1, 2.

When the counterguard is placed before the ravelin, ſet off 40 toiſes on the capital of the ravelin from the ſaliant angle A, to the ſaliant angle B, of the counterguard; and 10 from C to D, on the counterſcarp of the ditch.

When the counterguard is before the baſtion, ſuch as in fig. 2, its ſaliant angle F, is 50 toiſes from the ſaliant angle E of the baſtion, and the breadth near the ditch of the ravelin is 10 toiſes as before.

The ditch before the counterguards is 12 toiſes, and its counterſcarp parallel to the faces.

Counterguards are made before the ravelin, in ſome particular occaſions only, but are frequently conſtructed before the baſtions; as covering the flanks wonderfully well. Some authors, as *Blondel*, and Mr. *Coehorn*, will have them much narrower than they are here.

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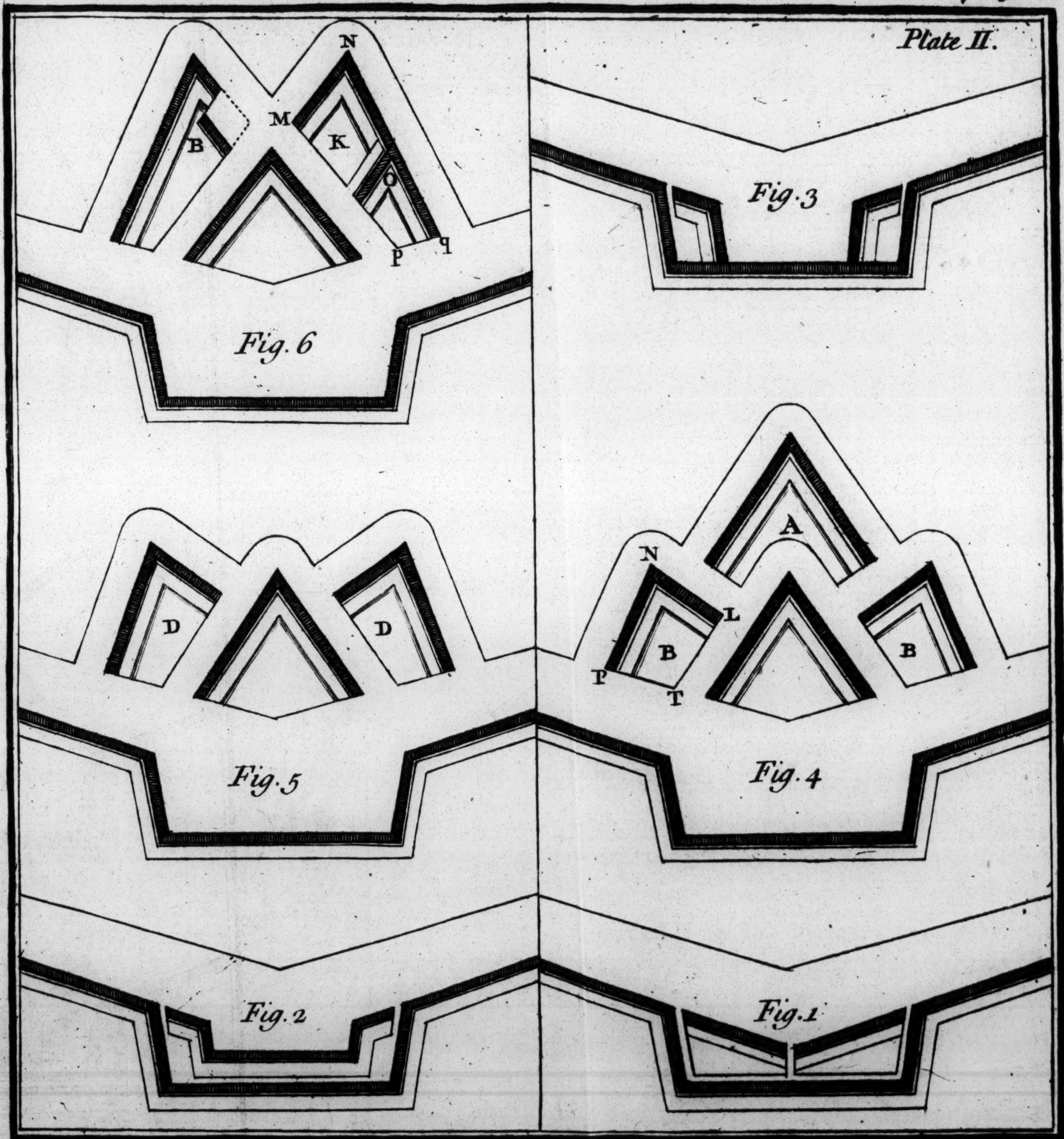
Plate II.
N
M
B
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Fig. 6
Fig. 3
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Fig. 5
Fig. 4
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Construction of Hornworks.

Produce the capital of the ravelin beyond the saliant angle A, at a distance AB of about 80 toises; draw DBE, at right angles to AB; in which take BD, BE, each equal to 55 toises; and on the exterior side DE, trace a front of a polygon in the same manner as that of the body of the place, making the perpendicular BF 10 toises, and the faces 30. Fig. 3.

The branches Da, Eb of the hornwork, when produced, terminate on the faces of the bastions, within 5 toises of the shoulders. The ditch of the hornwork is 12 toises, and its counterscarp parallel to the branches; and in the front, terminates at the shoulders, in the same manner as the great ditch before the bastions.

The capital of the ravelin before the front of the hornwork is 35 toises, and the faces terminate on the shoulders, or rather 2 or 3 toises beyond them; and the ditch before the ravelin is 8 toises.

There are sometimes retrenchments made within the hornwork, such as S, S; which are constructed by erecting perpendiculars to

 the

the faces of the ravelins, within 25 toiſes of their extremities. This retrenchment, like all others, has a parapet turfed only with a berm of 8 feet before it; as likewiſe, a ditch from 3 to 5 toiſes broad.

Fig. 4. When a hornwork is made before the baſtion; the diſtance DL, of the front from the ſaliant angle of the baſtion is 100 toiſes; and the branches terminate on the faces of the adjacent ravelins within 5 toiſes from their extremities; all the reſt is the ſame as before.

Conſtruction of Crownworks.

Plate IV. fig. 1. From the ſaliant angle A of the ravelin, as a center, deſcribe an arc of a circle with a radius of about 120 toiſes, cutting the capital of the ravelin produced at C; from the point C, ſet off the Cords CB, CF, each of them equal to 110 toiſes, and on each of which, as an exterior ſide, conſtruct a front of a polygon of the ſame dimenſions as in the hornwork; that is, the perpendicular ſhould be 18 toiſes, the faces 30, and the branches terminate on the faces of the baſtions, within 25 toiſes of the ſhoulders.

The ditch is 12 toiſes, the capital of the ravelin 35, and its ditch 8; that is, the ſame as in the hornwork.

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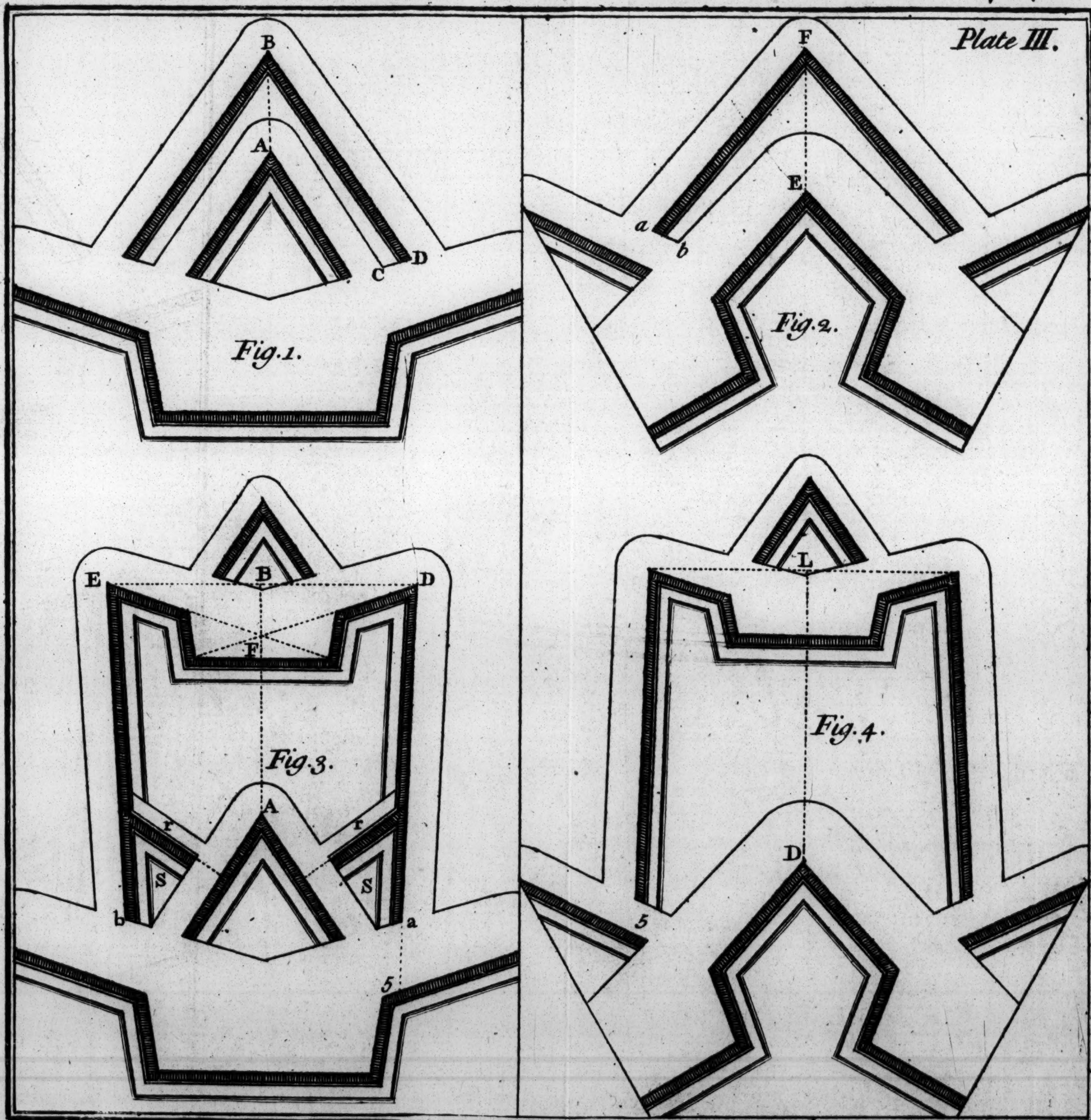

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Sometimes the crownwork is made before the baſtion, as in fig. 2; the arc is deſcribed from the ſaliant angle A, of the baſtion, with a radius of 120 toiſes, as before, and the branches terminate on the faces of the adjacent ravelins, within 25 toiſes of their extremities; the reſt of the dimenſions and conſtructions are the ſame as before. Fig. 2.

Hornworks, as well as crownworks, are never made, but when a large ſpot of ground falls beyond the fortification, which might be advantageous to an enemy in a ſiege, or to cover ſome gate or entrance into a town; they have notwithſtanding been uſed without judgment in ſeveral places, as at *Tournay*, *Ipres*, &c. Their advantages and diſadvantages ſhall be fully diſcuſſed in the third ſection.

Conſtruction of Covert-ways and Glacis.

Although we have not hitherto mentioned the covert-way, nevertheleſs, all fortifications whatſoever have one; for they are eſteemed to be one of the moſt eſſential parts of a modern fortification; and it is certain, the taking the covert-way, when it is in a good condition and well defended, is generally

nerally the moſt bloody action of the ſiege.

After having conſtructed the body of the place, and all the outworks which are thought neceſſary, lines are drawn parallel to the outmoſt counterſcarps of the ditches, at 6 toiſes diſtant from it; and the ſpace m n m n, included between that line and the counterſcarp, will be the covert-way required.

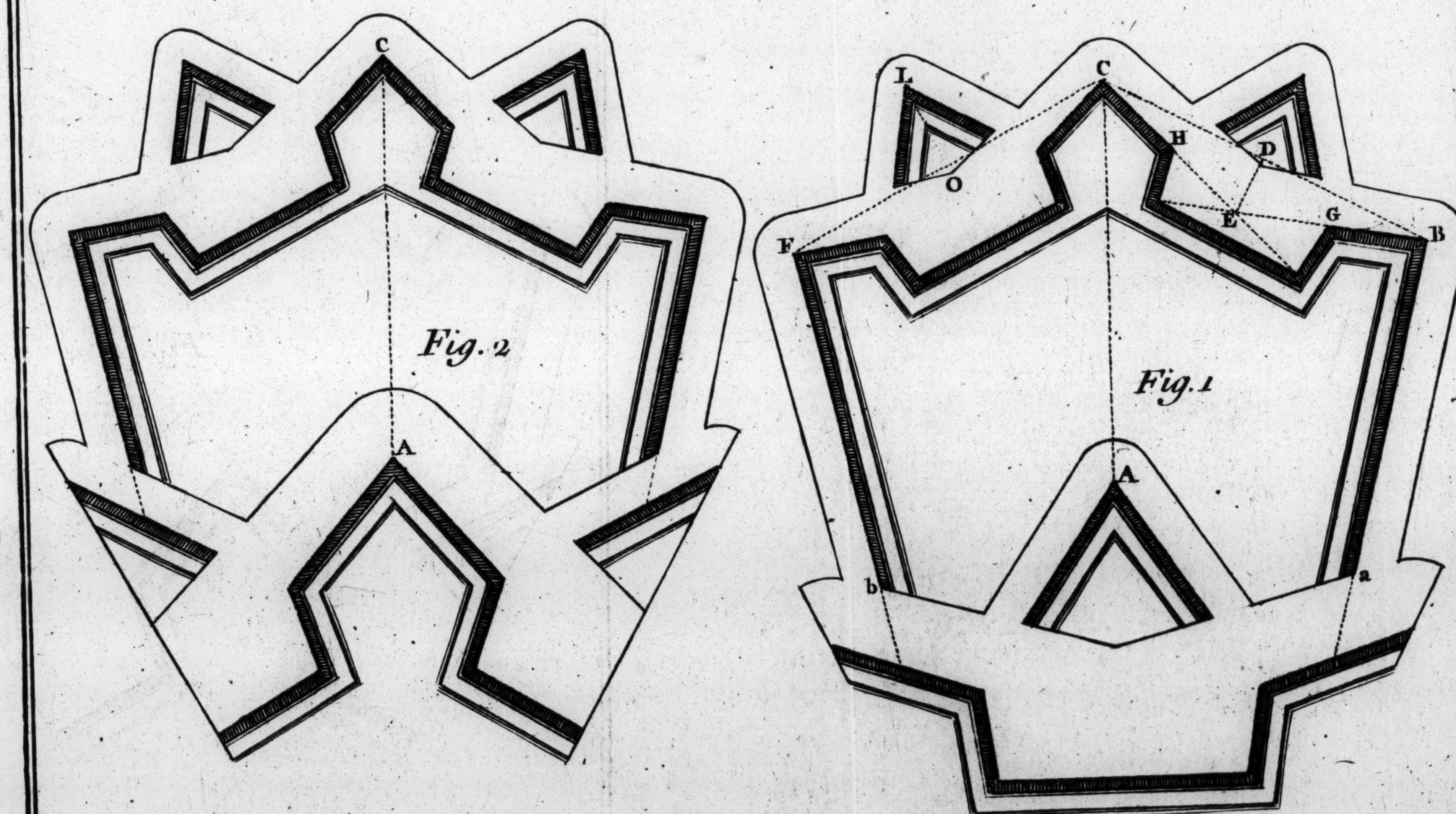
Plate V.

There is in every re-entring angle of the counterſcarp a place of arms, m; which is found by ſetting off 20 toiſes from the re-entring angle a, on both ſides from a to b, and from a to c; and from the points b, c, as centers, arcs are deſcribed with a radius of 25 toiſes, ſo as to interſect each other in d; then the lines drawn from this interſection to the points b, c, will be the faces of the places of arms.

If lines are drawn, parallel to the lines which terminate the covert-way, and the places of arms, at 20 toiſes diſtant from them, the ſpace x, x, x, between theſe lines and thoſe which terminate the covert-way, will be the glacis.

At the extremities of the places of arms, are traverſes made, ſuch as v, v, which ſerve to incloſe them; theſe traverſes are 3 toiſes thick,

Plate IV.



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thick, and as long as the covert-way is broad, and a paſſage is cut in the glacis, round them of about 6 or 8 feet, in order to have a free communication with the reſt of the covert-way.

There are alſo traverſes of the ſame dimenſions before every ſaliant angle of the baſtion and outworks, and are in the ſame direction of the faces of thoſe works produced; and the thickneſs lies at the ſame ſide as the parapets.

The paſſages round theſe laſt traverſes are likewiſe from 6 to 8 feet wide.

In each place of arms are two ſally ports z, z, which are 10 or 12 feet wide, for the troops to ſally out; in time of a ſiege they are ſhut up, with barriers or gates.

Conſtruction of Arrows, and detached Redouts.

An arrow is a work made before the ſaliant angles of the glacis, ſuch as A; it is compoſed of a parapet of 3 toiſes thick and 40 long, and the ditch before it 5 toiſes, terminating in a ſlope at both ends. The communication from the covert-way into theſe arrows, is 4 or 5 toiſes wide, and there is a traverſe r at the entrance of 3 toiſes

toiſes thick, with a paſſage of 6 or 8 feet round it.

A detached redout is a kind of work much like a ravelin, with flanks, placed beyond the glacis; ſuch as fig. B; they are made in order to occupy ſome ſpot of ground which might be advantageous to the beſiegers; likewiſe to oblige the enemy to open their trenches farther off than they would do otherwiſe.

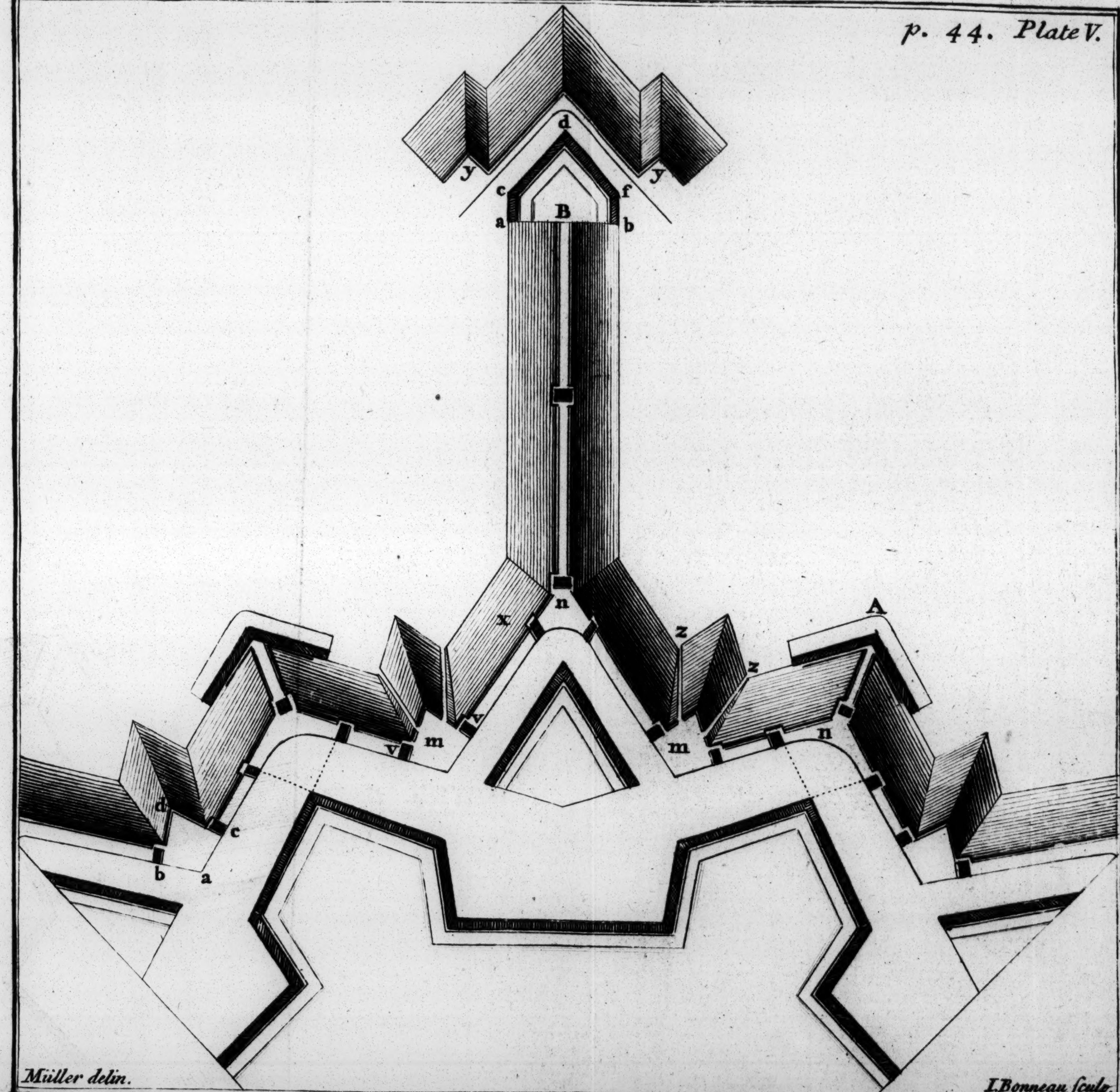
Their diſtance from the covert-way ought not to exceed 120 toiſes, that it may be defended by muſket-ſhot from thence.

The gorge a b is 40 toiſes, the flanks a c, b f, which are perpendicular to the gorge 10, and the faces c d f d 30; the ditch before it is 6 toiſes, ending in ſlopes at both ends; the covert-way 4; the branches of the covert-way are 12 toiſes long, or thereabouts; the faces of the places of arms y,y, which are perpendicular to the branches, 10; and the other, which is parallel to them, 14.

The communication from the covert-way into the redout, is 5 or or 6 toiſes wide; and there is a traverſe made juſt at the entrance; and another in the middle, when it is pretty long. The parapets of this communication terminate in a ſlope or glacis.

If

p. 44. Plate V.



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If theſe redouts are above 50 toiſes diſtant from the covert-way, the beſiegers carry their trenches round, and enter through the gorge; by which the troops that are in them are made priſoners of war, if they do not retire betimes: to prevent this, ſome other outworks ſhould be made to ſupport them.

Conſtruction of ſecond Ditches, and Covert-ways.

When the ground is low, and water to be found, there is often a ditch of about 10 or 12 toiſes made round the glacis; and oppoſite to the places of arms are conſtructed lunettes, beyond the ditch; ſuch as D, whoſe breadth on the counterſcarp of the ditch is 10 toiſes, and the faces are parallel to thoſe of the places of arms; the ditch before them is from 8 to 10 toiſes wide. Plate VI.

The ſecond covert-way is 4 toiſes, the ſemi-gorges of the places of arms about 15, and the faces perpendicular to the counterſcarp; the ſecond glacis is from 15 to 18 toiſes broad.

This ſecond covert-way has traverſes every where, in the ſame manner as the firſt.

These

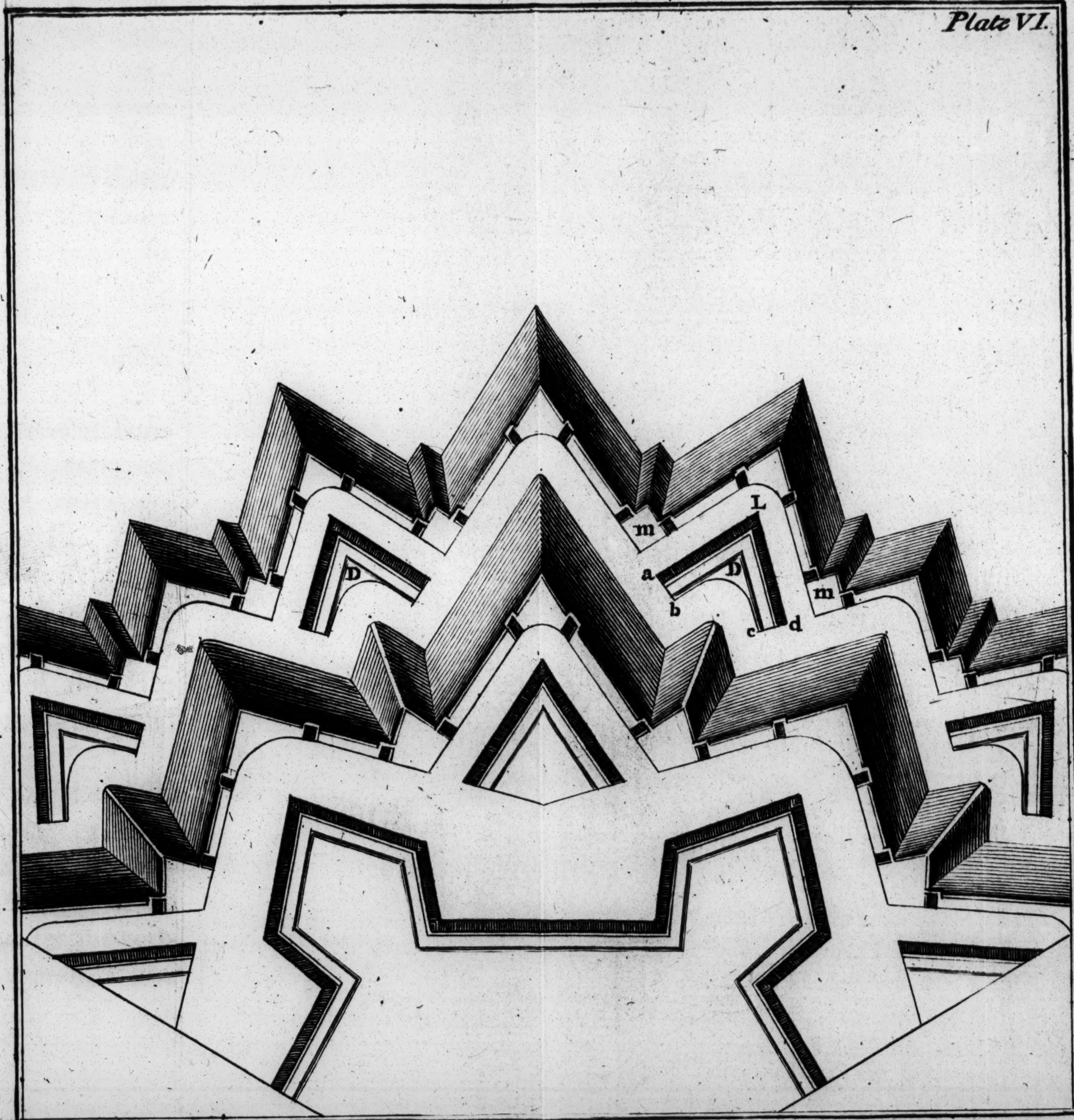
These are nearly all the different outworks, which are used now-a-days, in the construction of places: although they are generally ranked amongst M. *Vauban*'s works, yet none are of his invention, except the construction of the body of the place, and the circular flanks; for all the rest are to be met with in *Dilichiu*'s *Peribologia*, printed at *Frankford* in 1640: and it may be observed, that M. *Vauban* has chiefly copied this author, as *Coehorn* did *Spekel*.

Construction of Profils.

Plate VII. A profil is the representation of a vertical section of a work; it serves to shew those dimensions which cannot be represented in plans, and are necessary in the building of a fortification; they are generally constructed upon a scale of 30 feet to an inch. It would be needless to describe all their particular dimensions, since they are marked in the schemes; we shall therefore lay down the principal rules only, given by M. *Vauban*, on this subject.

1. Every work ought to be at least 6 feet higher than that before it, so that it may command those before it; that is, that the

Plate VI.



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the garifon may fire from all the works at the fame time, with great and fmall arms, at the befiegers in their approaches: notwithftanding this fpecious pretence, there are feveral authors, who object againft it. For they fay, if you can difcover the enemy from all the works, they can difcover by the fame reafon all the works from their batteries; fo that they may deftroy them without being obliged to change their fituation, and thereby difmount all the guns of the place before they come near it.

But if all the works were of the fame height, thofe within cannot be deftroyed, till fuch time that thofe before them are taken; guns might be placed in the covert-way and outworks to obftruct the enemy's approach, and when they come near the place, they might be tranfported into the inner works; and as the body of the place would be much lower, the expence would be confiderably diminifhed.

But when works are low, they are eafily enfiladed by the ricochet batteries, which is a kind of firing, with a fmall quantity of powder, by giving the gun an elevation of 10 or 12 degrees: this might, however, be partly prevented, by making the parapets near the

the ſaliant angles, for the ſpace of 8 toiſes on each ſide, five or 6 feet higher than the reſt of the works.

2. The covert-way ſhould be lower than the level ground, otherwiſe the body of the place muſt be raiſed very high, eſpecially when there are ſeveral outworks; this is to be underſtood only when the works exceed each other in height, otherwiſe it need not be below the level.

3. The baſes of all inward ſlopes of earth ſhould be at leaſt equal to the height, if not more.

4. The baſes of all outward ſlopes of earth two thirds of their heights.

5. The ſlopes of all walls or revetements ſhould be one fifth of their height; but one ſixth would be ſufficient in my opinion; the height of a wall is eſtimated from the bottom of the ditch, and not from the beginning of its foundation.

6. The ſlopes of all parapets and traverſes are one ſixth of their breadth; that is, 3 feet towards the field, or the inſide, where the banquettes ſhould be three feet higher than the outſide.

6. When the revetement of a rampart goes quite up to the top, 4 feet of the upper part is

is a vertical wall of three feet thick, with a ſquare ſtone at the top of it, projecting 6 inches, and a circular one below, or where the ſlope begins, of 8 or 10 inches diameter; they go quite round the rampart, and the circular projection is called the *Cordon*.

Where the ſtraight part of the wall ends and the ſlope begins, the wall is always made 5 feet thick; and the counterforts or buttreſſes reach no higher than that place.

7. When the rampart is partly walled and partly turfed; then one fifth of the height which is turfed, muſt be added to 5 feet, to get the thickneſs of the wall above.

And having the thickneſs of any wall above, by adding one fifth of its height from the bottom of the ditch, the ſum will be the thickneſs of the wall at the bottom; but if a ſixth part is only taken for the ſlope, then a ſixth part muſt be added.

For inſtance, ſuppoſe a rampart of 30 feet high from the bottom of the ditch, and that 10 of which are to be turfed; then the fifth part of 10, which is 2, added to 5, gives 7 for the wall above; and as this wall is 20 feet high, the fifth of which is 4, and 4 added to the thickneſs 7 above, gives 11 for the thickneſs near the foundation.

The ſeventh plate repreſents in military perſpective the profils of the body of a place, the ravelin and covert-way, which gives a clear idea of what is meant by a profil; and from which thoſe of all other works may be eaſily conceived.

M. *Vauban* gives in the following table the dimenſions of walls from 10 to 80 feet high, from 10 to 10 feet.

Height of the wall.	Thick-neſs a-bove.	Thick-neſs be-low.	Diſtances between the cen-ters of the counter-forts.	Diſtances between the cen-ters of the counter-forts.	Length of the counter-forts.	Thick-neſs near the wall.	Thick-neſs at the other end.
10	5	7	18	15	4	3	2 : 0
20	5	9	18	15	6	4	2 : 8
30	5	11	18	15	8	5	3 : 4
40	5	13	18	15	10	6	4 : 0
50	5	15	18	15	12	7	4 : 8
60	5	17	18	15	14	8	5 : 4
70	5	19	18	15	16	9	6 : 0
80	5	21	18	15	18	10	6 : 8

All theſe numbers are feet, except in the laſt column, which are feet and inches. M. *Vauban* adds, that when the ſtone or

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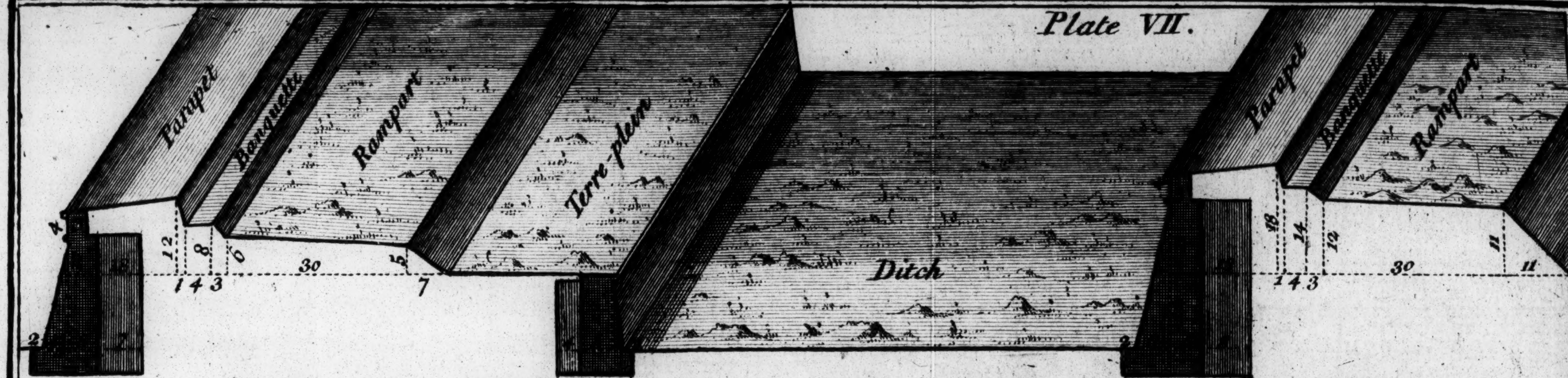
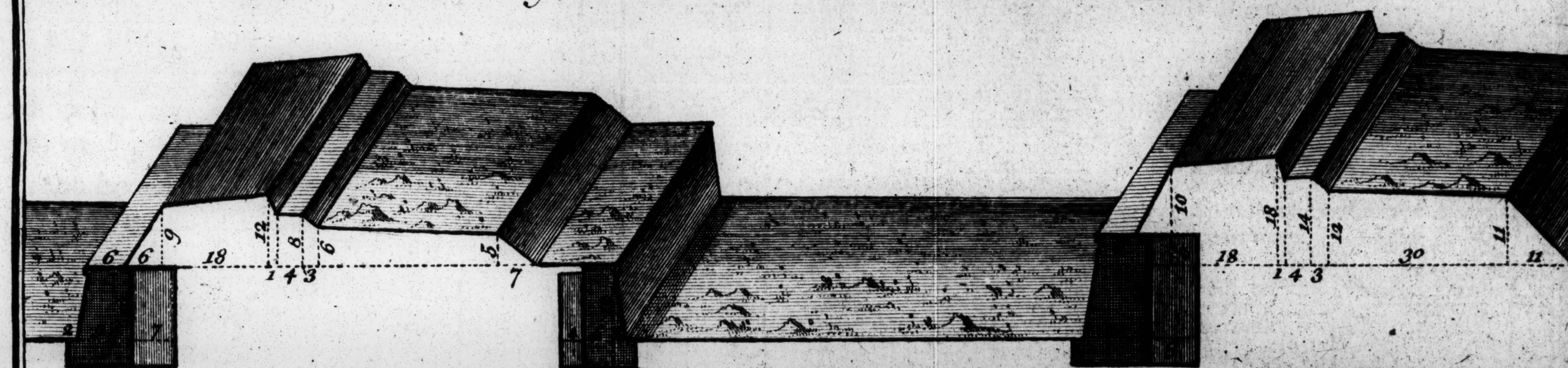
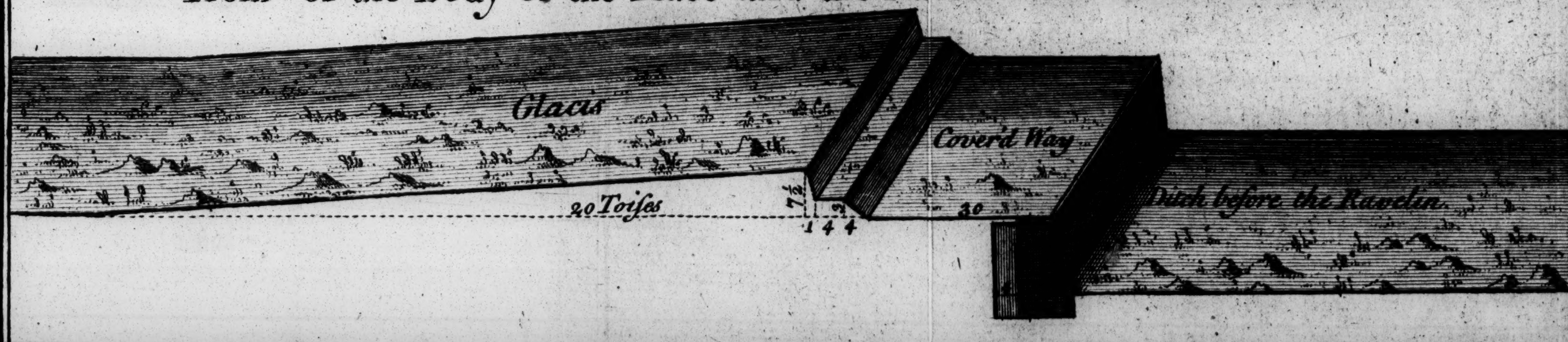
Plate VII.



Profil of the Body of the Place and the Ravelin with Revetement.



Profil of the Body of the Place and the Ravelin with demi-Revetement.



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brickwork is very good, the thickneſs of the wall above may be reduced to 4 $\frac{1}{2}$ feet or 4 only; but when it is bad, it may be encreaſed to 5 $\frac{1}{2}$ feet, and ſometimes more.

That the counterforts at the ſaliant angles ſhould be well braced or bound together.

When the ramparts are partly turfed and partly walled, he makes the intervals between the centers of the counterforts but 15 feet; but when they are walled quite up to the top, theſe diſtances are 18 feet.

Theſe dimenſions have been uſed in the conſtructions of a great many places, and the walls have never failed; it may be demonſtrated, that his low walls are too ſtrong, and the high ones too weak: but this ſubject ſhall be examined in the ſecond book, where practical fortification is treated of.

Conſtruction of M. Vauban's *ſecond method, with Tower-baſtions, according to the plans of* Landau *and* Beſford.

This method is adapted to the fortifying of places built already; for which reaſon, he begins his conſtruction inwards and for-

tifies outwards, contrary to his other methods, as being more convenient for that purpose.

Plate VIII. Let AB be the interior side of an exagon of 120 toises, draw AC, BD, from the center through the extremities of the sides: set off 6 toises from A to b, and from B to c; thro' the points b and c, draw lines at right angles to AB; from the point b set off 6 toises to f outwards, and 4 from b to d inwards; and from the points f, d, draw perpendiculars f r, dn, to the capital AC; then if rE is made equal to rf, the point E will be the saliant angle of the tower bastion; and E f d n half that tower.

If in the capitals, there be taken from the saliant angles of the tower bastions, the distances EC, FD, of 40 toises, the points C and D will be the saliant angles of the counterguards before the towers: from the points C and D draw the lines of defence Cc, Db, to the points where the flanks of the towers cut the curtain: on which set off 56 toises for the faces of the counterguards, the flanks are found as in the first method, and likewise the tenailles.

The ditch before the saliant angles of the towers is 6 toises, and its counterscarp drawn to the extremities of the flanks of the counterguards;

guards; the right line which joins the ends of theſe flanks will determine the inſide of the tenailles.

The ditch before the counterguards is 12 toiſes at the ſaliant angles, and the counterſcarp is drawn to the oppoſite ſhoulders in the ſame manner as in the firſt method.

The capital of the ravelin is 45 toiſes, its faces when produced, terminate on thoſe of the counterguards, within 10 toiſes from the ſhoulders; 10 toiſes are cut off from the faces by the flanks which are parallel to the capital as uſual.

The ditch before the ravelin is 10 toiſes, the covert-way 5, the ſemi-gorges of the places of arms 12, the faces 17, and the glacis 20.

Conſtruction of M. Vauban*'s third method, according to the plan of* New-Briſach.

This method is applied to an octagon, whoſe exterior ſide AB is 180 toiſes, the perpendicular CD, 30; the faces AK, BL of the counterguards 60: the flanks LN, KM are found by ſetting off 22 toiſes, as chords to the arcs deſcribed from the oppoſite ſhoulders as centers: from the extremities of the flanks a Plate IX.

line is drawn, which will be parallel to the exterior ſide AB, meeting the capitals AE, BF of the counterguards at G and H; this line terminates the inſide of the tenaille, as likewiſe the ſaliant angles G, H of the tower baſtions.

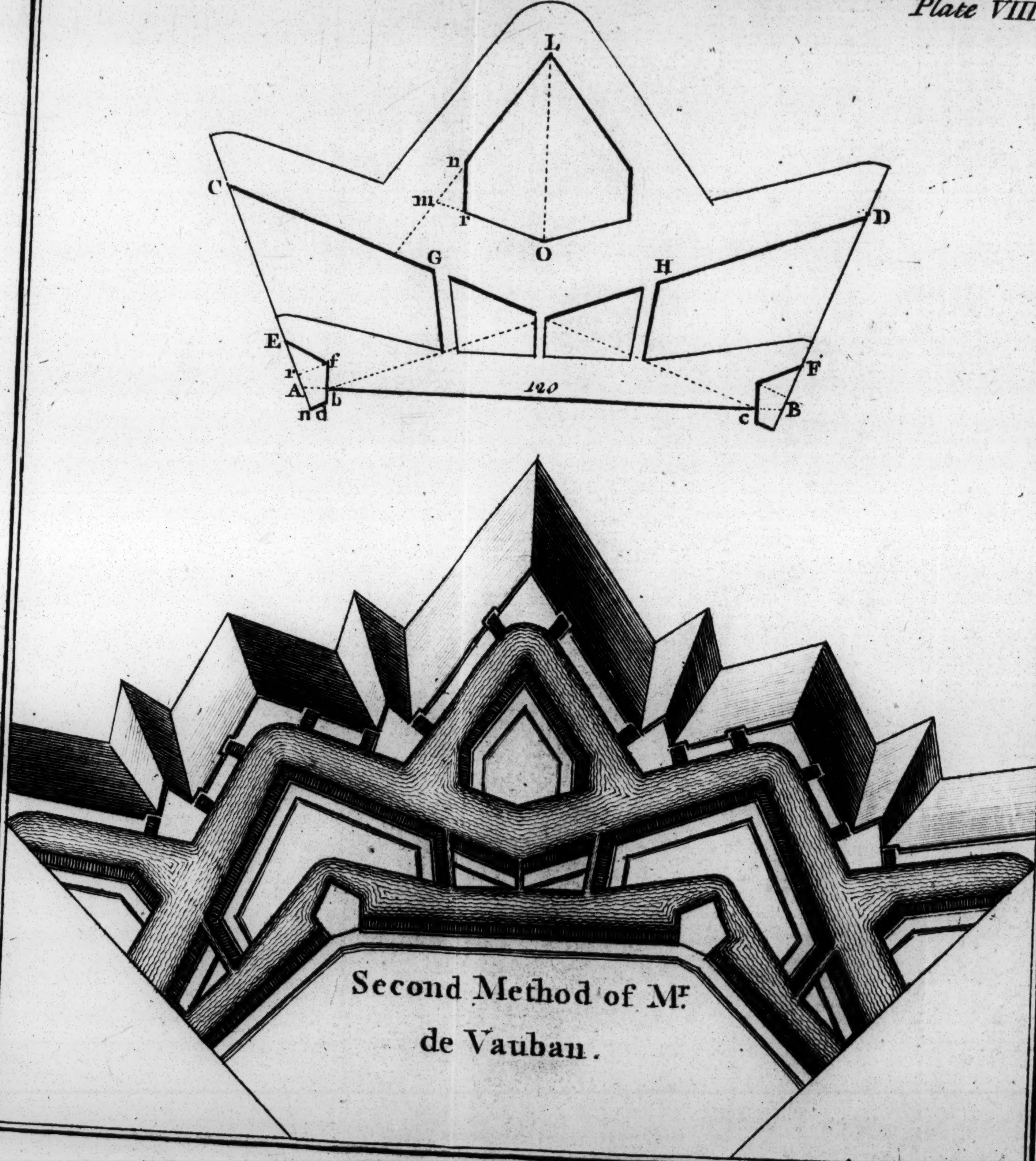
If EF be drawn parallel to GH, and at 9 toiſes diſtant from it, the interſections E, F, with the capitals of the counterguards, will be the centers of the towers; from which ſet off 7 toiſes to *a* for the ſemi-gorges, and draw the flanks bc through the extremities of theſe ſemi-gorges perpendicular to the line EF; theſe flanks are 4 toiſes inwards from *a* to c, and 5 outwards from *a* to b; the faces bG are drawn from the point b to the point G, and the lines joining the inſide of the flanks at the end of 4 toiſes will compleat the towers.

The ditch is 6 toiſes before the ſaliant angle of the towers, and its counterſcarp meets the line GH, within 10 toiſes of the extremities M, N, of the flanks of the counterguards.

If from the point n, where the line EF interſects the perpendicular CD produced, you ſet off 5 toiſes to the point r, and the lines of defence are drawn from the extremities of the ſemi-gorges *a* of the towers through

p. 54.

Plate VIII.



Second Method of Mr. de Vauban.

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through this point r; then the flanks of the counterguards produced will determine the little flanks p q of the inſide rampart, and the extremities of theſe little flanks being joined, will give the curtain between them.

The great ditch before the counterguards is 15 toiſes, and its counterſcarp parallel to the faces: the capital of the ravelin is 55 toiſes, and that of the redout within it 23; the faces of the ravelin are drawn to the faces of the counterguards within 15 toiſes from the ſhoulders, and thoſe of the redout parallel to theſe: 12 toiſes are cut off from the faces of the ravelin, and 6 from thoſe of the redout, by the flanks which are parallel to the capital; the ditch before the ravelin is 12 toiſes, and that before the redout 6: the covert-way and glacis are the ſame as in the ſecond method: the profils in plate X, XI, referred to this method, may ſerve likewiſe for the ſecond. It muſt be obſerved, that the parapets of the counterguards, on both ſides of the ſaliant angles, are raiſed 4 feet higher, for the ſpace of 20 feet, above the reſt, to prevent the enfilades of the ricochet batteries.

We ſhall examine theſe two laſt methods in the third ſection, in order to ſhew their perfections and imperfections.

Construction of M. Coehorn's *first method.*

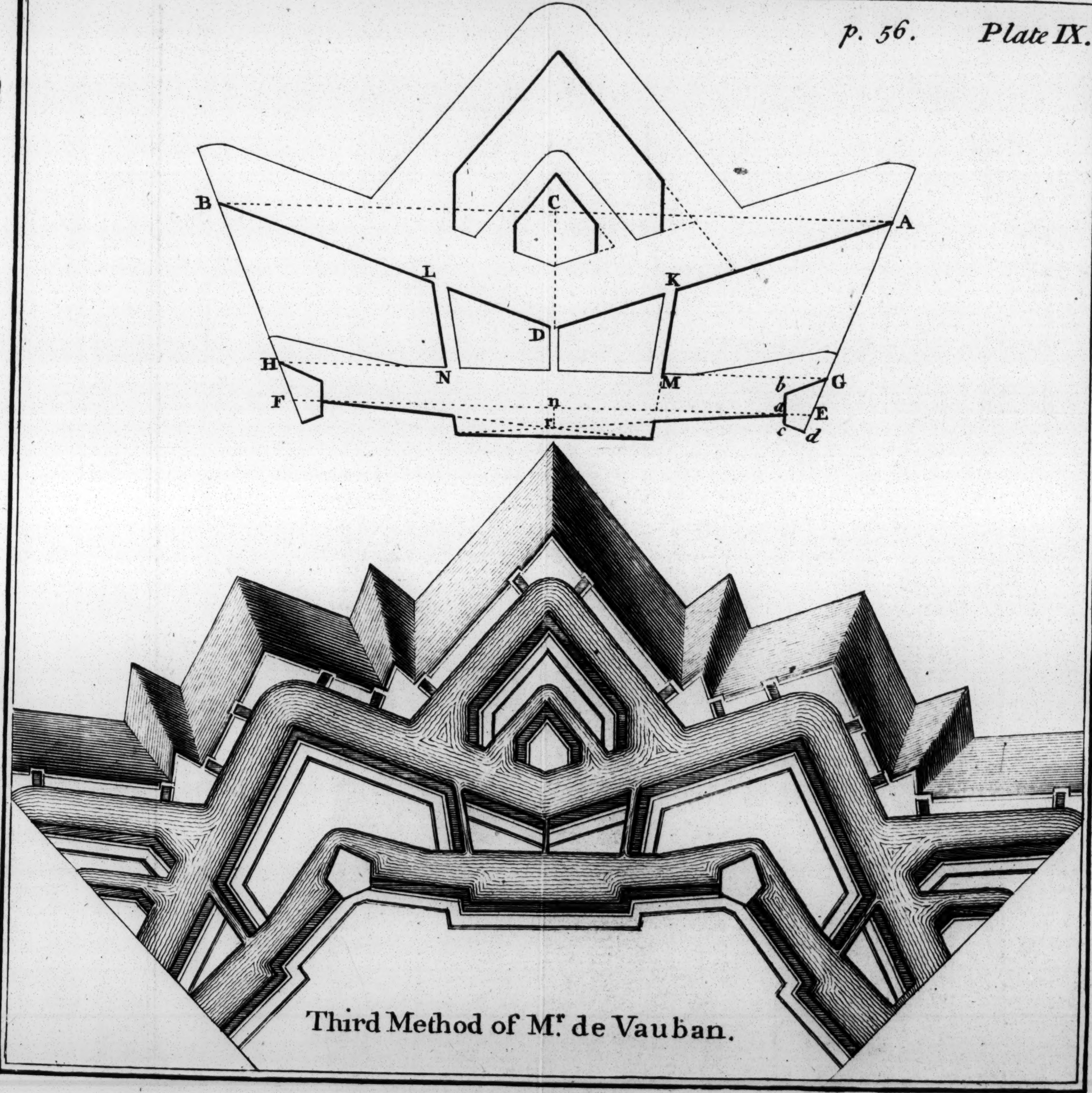
Plate XII. This author applies his first method to an exagon, and supposes that the surface of the water is but 4 feet lower than the level ground.

Let therefore the interior side AB of an exagon be 150 toises, take AC, BE, each equal to 39, and in the capitals AE, BF, each of 80; and AG, BH, of 40; from the points E, F, draw the lines of defence through the points D, C; and through the points G H, lines parallel to ED, FC; in which take GI, HK, each equal to 40 toises, for the length of the higher faces of the bastions.

Fig. 2. To determine the lower faces EM, FN, draw IO perpendicular to IG, equal to 4 toises; O r, parallel to IG, likewise equal to 4; then r M perpendicular to EM will determine the lower face EM.

In order to determine the tower 3, see fig. 2; in rM, take rS of 5 toises, draw Sm parallel to EM, and equal to 14; in Or produced, take likewise rn equal to 4, and in EM, MV to 8; then if the points n, m

are



Third Method of Mr. de Vauban.

Profil of Mr. de Vauban's

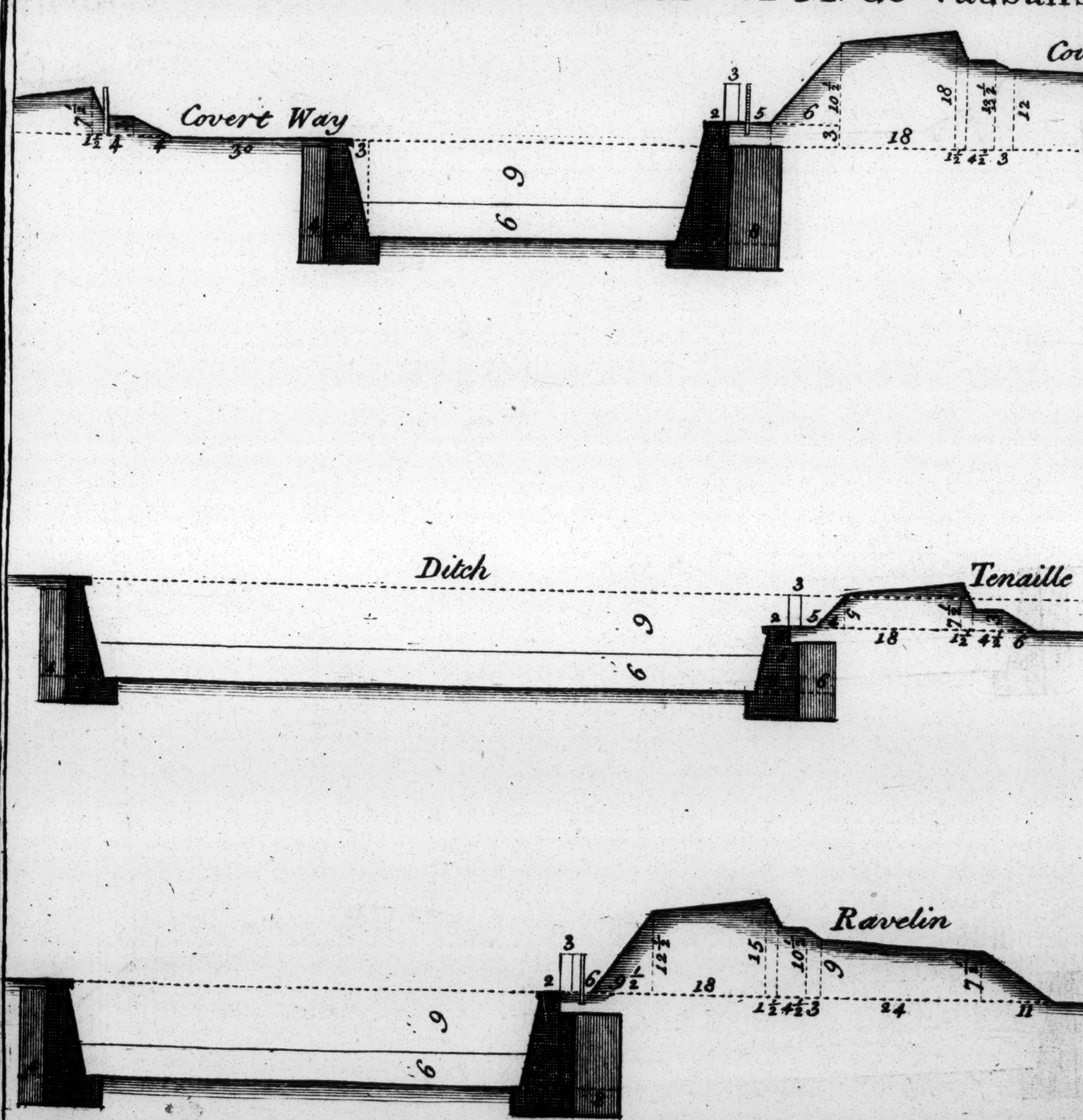
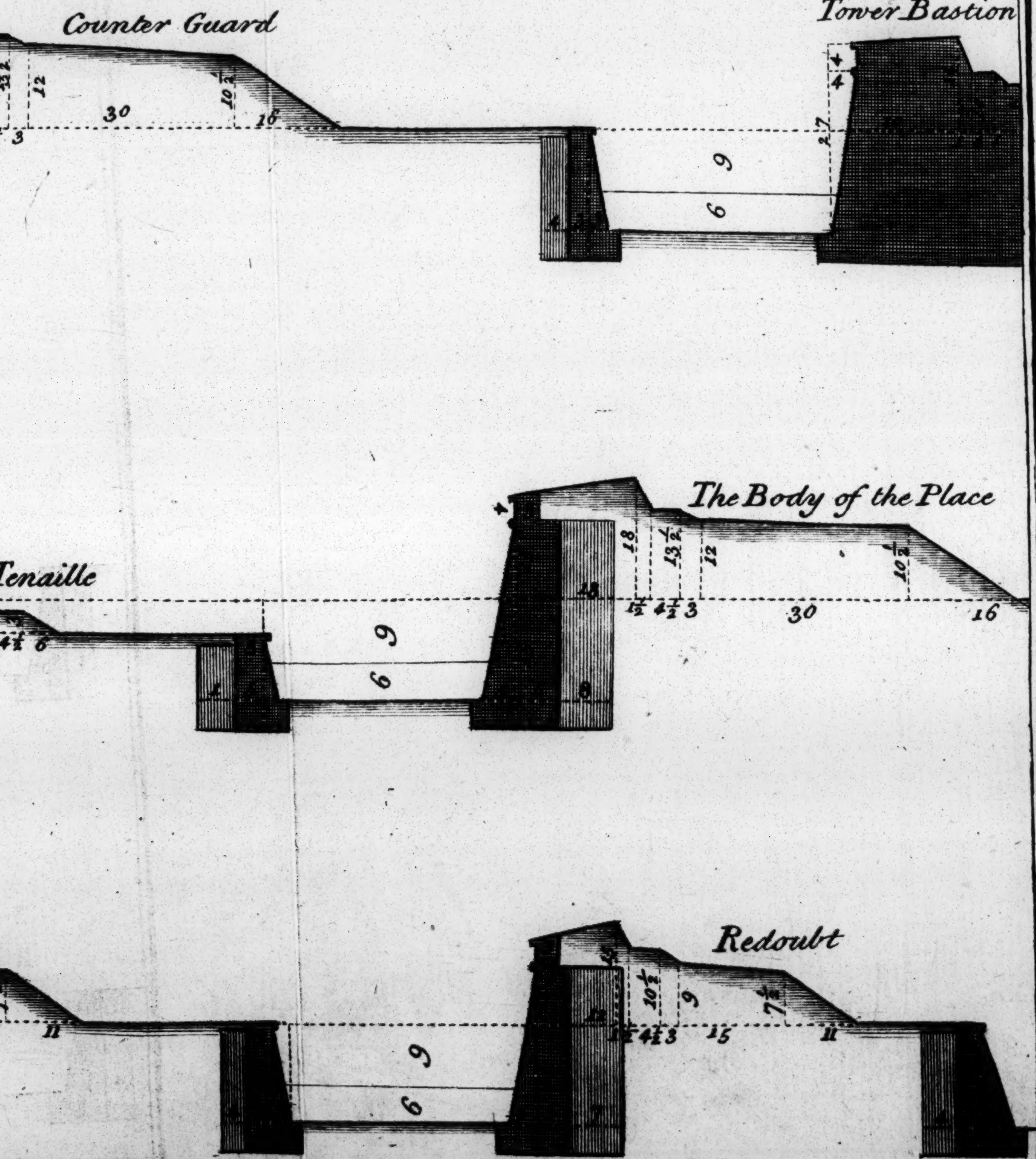
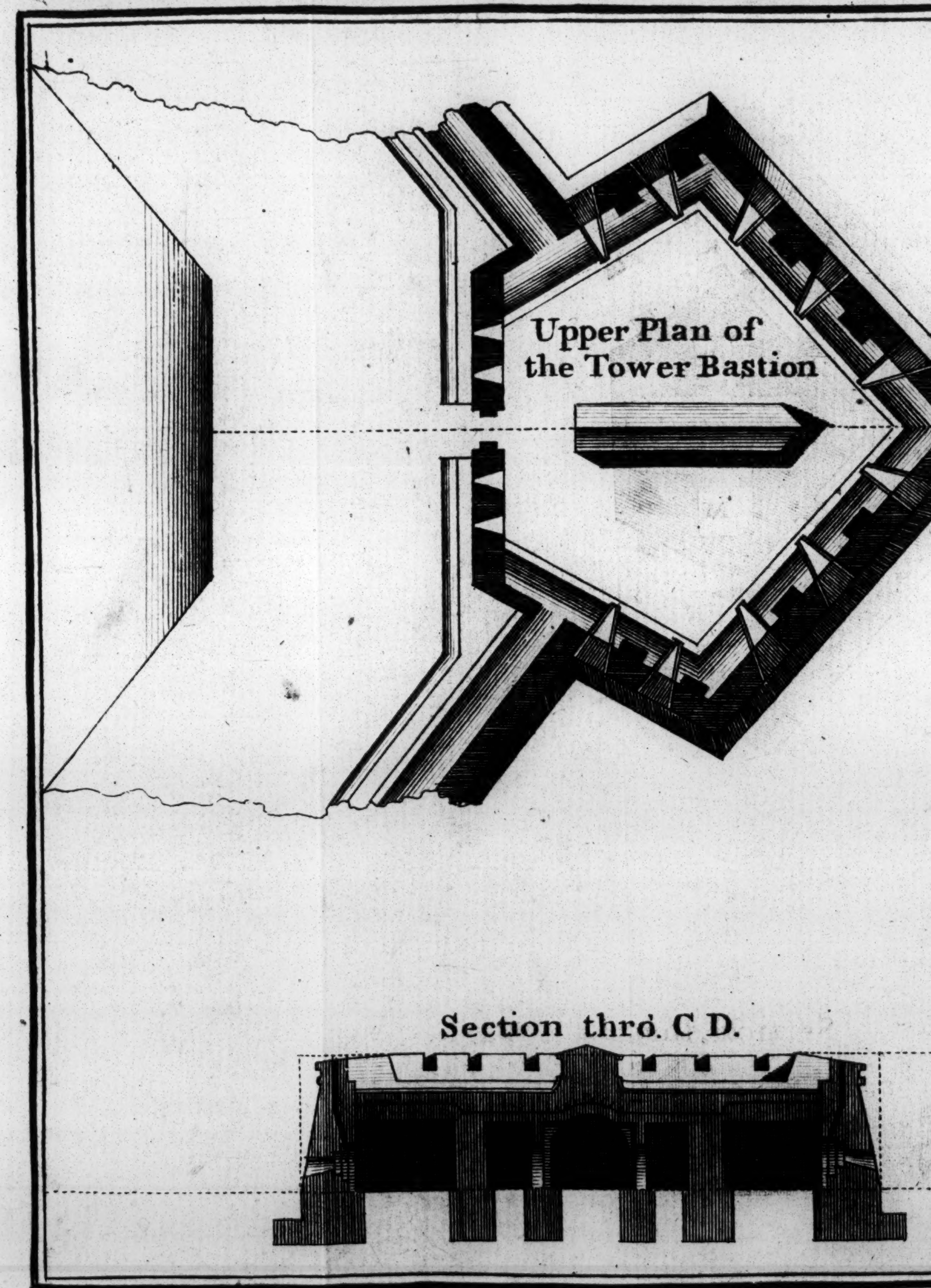


Plate X.

uban's third Method





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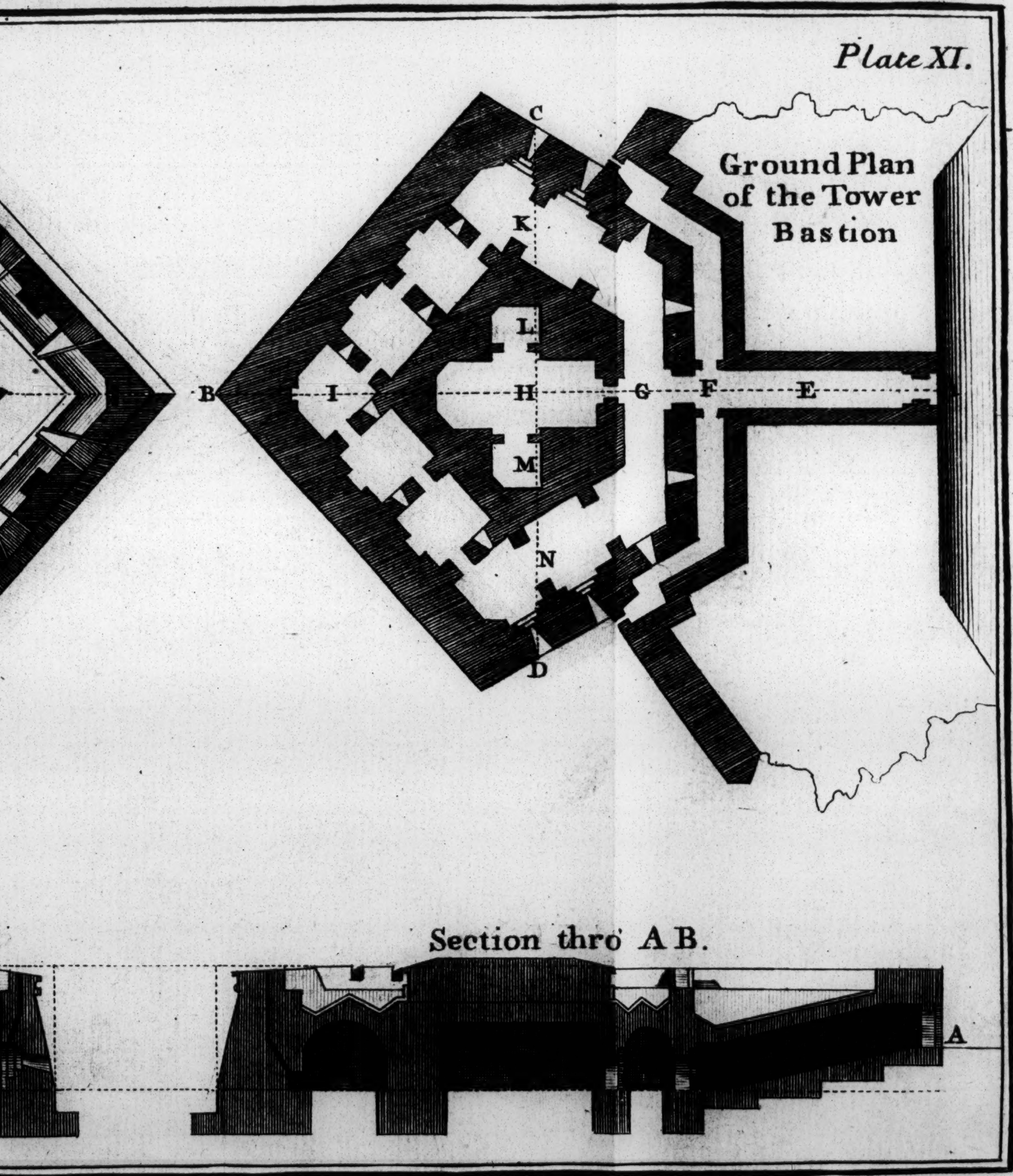
Plate XI.
Ground Plan
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are joined by a right line, and m, v, by an arc of 60 degrees, you will have the outline of the tower.

The lines IO and Or, expreſs two walls, the firſt has two embraſures, and the ſecond three; by which the author intended to defend the dry ditch, and the approach to the tower.

If from the points C, D, there be ſet off on the lines of defence 14 toiſes to the points Y, W; and upon each of the baſes YI, WK, be deſcribed an equilateral triangle, the angles oppoſite to theſe baſes, will be the centers of the higher flanks YI, WK.

And if R be the interſection of the two lines of defence, RM biſected at S, and RC at Q; by drawing SQ, *v*SQR will be half the tenaille; and drawing from the point C, a line parallel to IY, ſo as to meet the tower, upon which the mean flank is deſcribed in the ſame manner as the former.

The parapets of the three flanks, and thoſe of the parts mV, VM, of the towers, are 24 feet thick; the other parts Mr, rnm, but 16; and all the other parapets in general are 20 feet. Fig. 2.

There is a wet ditch before the mean flank of 6 toiſes broad, and another z, behind

hind the towers of the ſame breadth, over which are made two draw-bridges, parallel to the higher faces.

The ſpace X between the higher and lower faces of the baſtions is a dry ditch, whoſe bottom is but 6 inches above the ſurface of the water in the wet ditch.

Behind the lower parapet there is a banquette of 3 feet and a rampart of 5; and under this rampart a ſtone gallery, which runs from one end to the other, and is divided into ſeveral apartments, which are ſhut with doors; as likewiſe another, going from the ſaliant angle of the lower faces, to that of the higher, with loop-holes from diſtance to diſtance facing the dry ditch: there is likewiſe a row of paliſades placed parallel to the higher faces, and at 4 toiſes diſtant from them.

There are three embraſures in Or, as has been ſaid, to flank the ditch z behind the towers; and two in IO to flank the dry ditch near the higher faces.

The great ditch is 24 toiſes broad, and its counterſcarp parallel to the lower faces of the baſtions; the ſemi-gorges OL of the ravelin are 29 toiſes, and the faces LP, 45; the dry ditch Y is 16 toiſes, the rampart 28 feet, and the lower faces aT are parallel to the higher

higher ones; the parapet of which is 20, and the banquette 3.

The level ground of the rampart in the ravelin near the ſaliant angle is 20 feet broad, for the length of 20 toiſes from that angle, and the reſt but 15.

In the gorge of the ravelin is a ſmall redout *a*, of about 5 feet high, and underneath a lodgment of ſtones, the walls being 18 inches thick as the ſides; the roof is made of planks, with 3 feet earth over them.

There is a dry ditch going from the extremities of the faces to the redout, and round its angle, having a row of paliſſades before it, to ſecure the retreat from the ravelin into this redout; there is likewiſe another row going from the extremities of the faces, in a round form, turning towards the gorge of the ravelin.

In the dry ditch of the ravelin, within 6 toiſes from the great ditch is a coffer, and a ditch p of 6 toiſes before it: this coffer has a wall on both ſides, and the roof is planked and covered with a foot and half of earth; above this, is a ſtone parapet of 5 feet high, with a banquette behind it.

There runs a covered gallery under the rampart of the lower faces, and another

joining the two saliant angles, together with a row of palissades, in the same manner as in the dry ditch of the bastions.

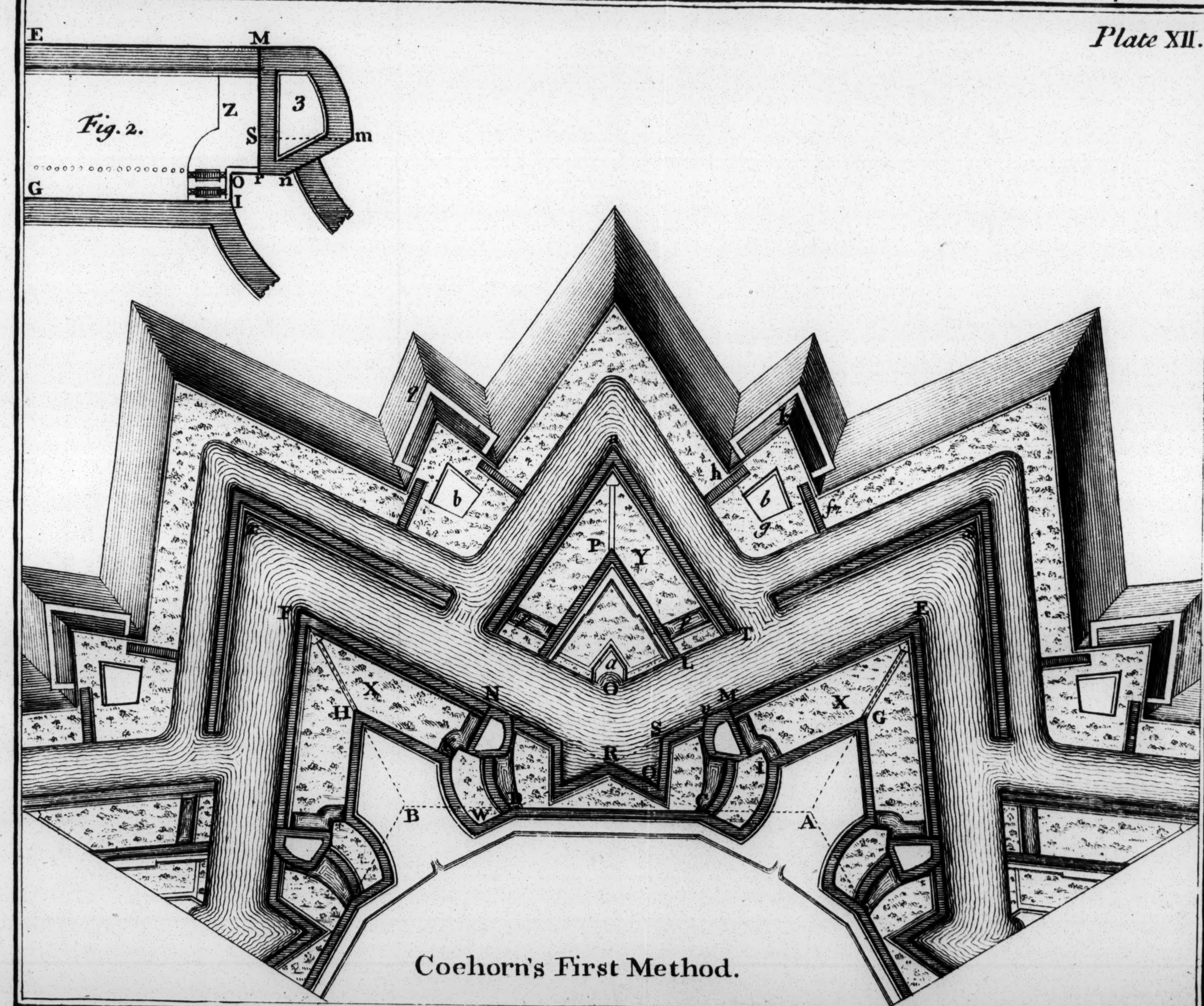
The wet ditch before the ravelin is 18 toises; the counterguards *x*, which the author calls *cover-faces*, are 25 feet broad, and the ditch before them 14 toises; the covert-way is 12 toises broad and the glacis 20; the semi-gorges f g, g h, of the places of arms, are 22 toises, and are taken from the point g, where the branches of the covert-way meet, and the faces f k, h k, are 28; within these places of arms are traverses of 20 toises broad and 18 long, within 10 or 12 feet from, and parallel to the faces.

The stone lodgments b, within the places of arms, are found by setting off 12 toises from the point g, for the semi-gorges, and the faces are drawn parallel to those of the places of arms.

At 6 toises from the places of arms, are coffers q of 8 feet broad, made with planks at the sides, and above with a foot of earth over and before them.

There are two banquettes all round the covert-way, and before the traverses; as also two rows of palissades before the traverses, one of which joins them, and the other goes round the covert-way. La

Plate XII.



Coehorn's First Method.

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Laſtly, the re-entring angles of the counterſcarp next to the covert-way are made a little round, as likewiſe that in the ravelin; but the contrary way, that is, they are made hollow.

Conſtruction of M. Coehorn's *ſecond Method.*

The author ſuppoſes an eptagon, whoſe interior ſide is 126 toiſes, and the level of the ground to be 3 feet above the ſurface of the water. Pl. XIII.

Let, therefore, the interior ſide AB of an eptagon, be 126 toiſes, take in the capitals, AC, BD, each of 72 toiſes; at the extremities C, D, make the angles ACE, BDF, each of 40 degrees; and ſet off 66 toiſes for the faces CE, DF of the baſtions; on the interior ſide, take AG, BH, each of 30 toiſes, and from the point D as center, deſcribe an arc through the point G, on which ſet off a chord of 30; and on this chord deſcribe the mean flank GI, which is an arc of 60 degrees.

Draw a line from the ſaliant angle D through the extremity I of this flank, on which take Ia of 10 toiſes; join aE, on which deſcribe the orillon as uſual.

The

The outline of the higher flank is 12 toiſes diſtant from that of the outline of the mean; this flank is an arc deſcribed from the ſame center as that of the former, the chord of which is 40 toiſes.

From the points G, H, draw the broken parts of the curtain perpendicular to the capital of the baſtion, and make it 9 toiſes long: the extremity of the higher flank is terminated, by the inſide line of the parapet of the curtain produced.

The tenaille is found by producing the faces of the baſtions 10 toiſes; through the extremity of which, an arc is deſcribed from the oppoſite ſaliant angle of the baſtion, as center; on this arc is ſet off a chord of 20 toiſes; and this chord ſerves to deſcribe the flank upon, which is an arc of 60 degrees; the curtain is a right line.

There is a wet ditch before the tenailles of 10 toiſes broad, with two bridges at each end, near the orillons; the one directly over it, and the other along the faces of the baſtion.

The dry ditch round the body of the place is 20 toiſes broad, before the faces of the baſtion to which it is parallel, and the lower rampart KL 29 feet; the ſemi-gorges ML

ML are 15 toiſes, and the flanks LN, 18, and are deſcribed from the ſaliant angles K of the lower faces as centers.

The ſaliant angle of the ravelin is 125 toiſes diſtant from the curtain of the body of the place, and is 70 degrees; the faces are 50 toiſes long; the faces of redout x, are 16 toiſes diſtant from thoſe of the ravelin, and 14 long.

The wet ditch round the lower faces of the ravelin is 24 toiſes broad; the work beyond this ditch, which the author calls the ſecond counterſcarp, is 20, parallel to the ditch.

To find the broken part of this work, join the two re-entring angles m, r; on which take mr, of 30 toiſes, and draw rt, rv parallel to the outline of the counterſcarp, each equal to 12; ſet off 22 from t, to s, and from v to Q; and upon theſe lines as chords deſcribe the round flanks, which are arcs of 60 degrees.

The traverſes in this counterſcarp are drawn at 10 toiſes from the flanks perpendicular to the parapet.

The redouts z in the re-entring angles, are found by ſetting off 16 toiſes from the points m, to n for their capitals, and the faces are parallel

parallel to the broken curtain before them: those marked y which are in the saliant angles found by producing the counterscarps of the great ditch, and setting off 12 toises from the points of their intersections for their faces; and the flanks are drawn parallel to their capitals.

The ditch before this work is 14 toises; as to the covert-way and glacis, they are the same as in the author's first method.

Construction of M. COEHORN'*s third method.*

Pl. XIV. The author supposes an octagon, whose interior side AB is 110 toises; the semi-gorges An, Bm, 21; the capitals AC, BD, of the bastions 64; and the saliant angles 85 degrees; the faces CE, DF of the bastions 54 toises; the parts Qs, Qr of the tenaille 32; the lower flanks, that is, those of the tenaille, are found by describing arcs through the points s, r; from the opposite saliant angles DC, on which are 20 toises set off as chords; and these chords serve to describe arcs of 60 degrees upon, for the required flanks.

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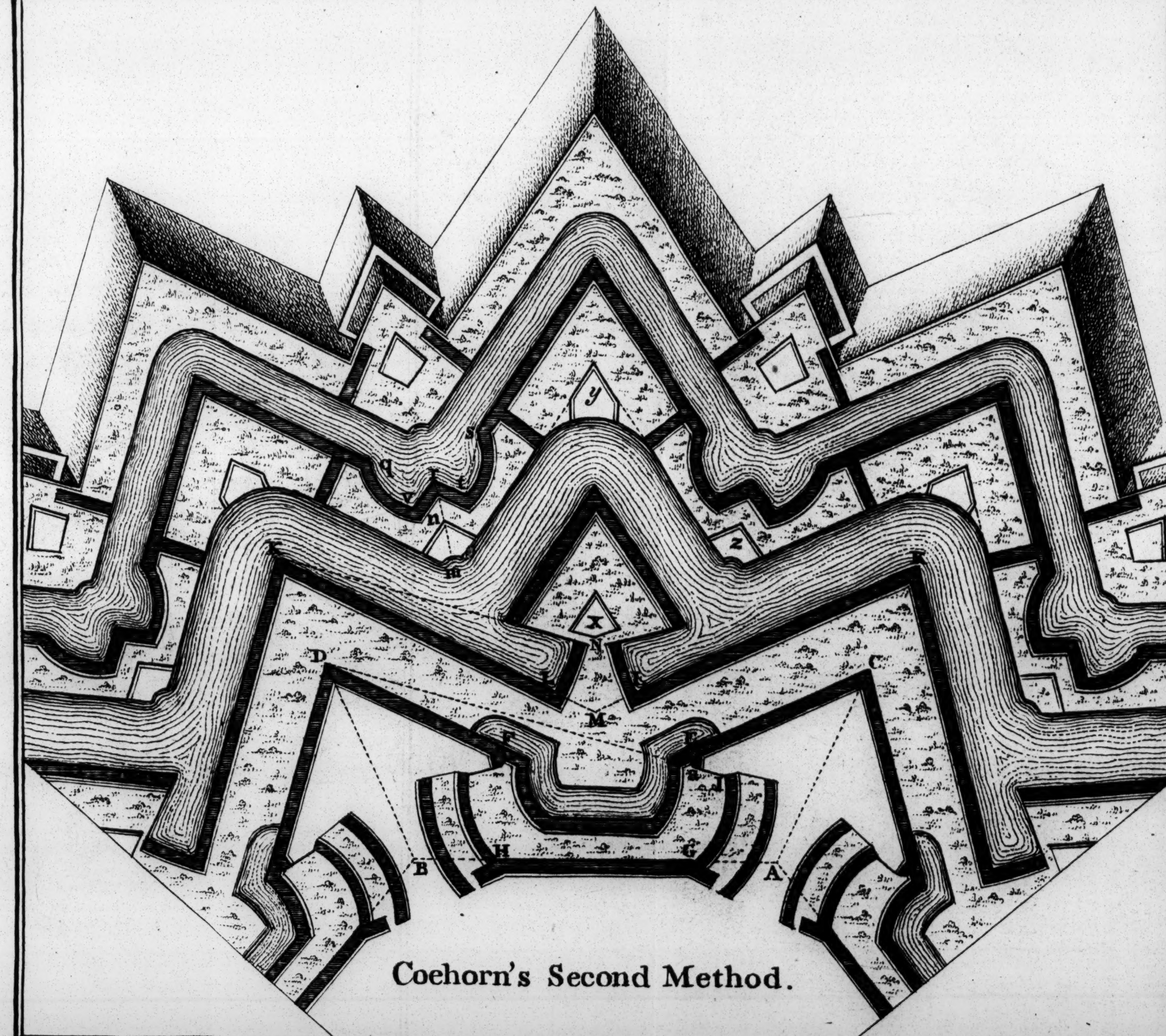
Plate XIII.



Coehorn's Second Method.

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From the extremities v, t, of theſe flanks, lines are drawn to the oppoſite angles D, C, and 6 toiſes ſet off from v to q; and upon q E the orillon is deſcribed as uſual.

The higher flanks are deſcribed from the ſame centers, as the lower through the extremities n, m, of the curtain; and their chord is 30 toiſes.

The wet ditch before the body of the place is 20 toiſes, and its counterſcarp parallel to the faces of the baſtions.

The capital V W of the detached baſtion is 100 toiſes; the faces are directed to the ſaliant angles of the inner baſtions; the dry ditch behind the lower faces in the detached baſtions are 20 toiſes; and the higher faces are parallel to the lower, and 31 toiſes long: e towers x, and the ditch before them, are ade in the ſame manner as in the firſt method. To find the flanks, make the ſemi-gorges V a, V b, each 38 toiſes, and draw the chords off theſe flanks parallel to the capital V W; and from the extremities of the higher faces draw alſo lines to the former, upon which the flanks are deſcribed as uſual.

The counterſcarp of the ditch before the redout z, is drawn from the extremities of

the flanks parallel to the faces; and at 6 toises from this the faces of the redout are drawn; 4 toises of which are cut off for the flanks.

The Ditch before the detached bastion is 24 toises; the ravelins, counterguards, covert-way, and glacis, are the same here as in the first method.

There are little pits or ponds l, l, dug between the higher and lower curtains, to hold water, in order to prevent the passing from the tenailles to the flanks.

SECTION III.

Containing the general Maxims of Fortification, applied in the Remarks on the preceding Authors, and others mentioned hereafter.

IN learning fortification, with an intention to make any progress in it, it is not sufficient to be capable of drawing lines, and to know the names of the different works; but it is necessary to be well acquainted with the principles or foundation on which the perfection

p. 66.

Plate XIV.

Coehorn's third Method

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fection and imperfection of a work depends; to be able to give reasons for what is done, and to be in a condition to judge upon good grounds, what is good and what is not so, in the various manners of fortifying, by all the different authors who have wrote on this subject.

There are three considerations essentially required in a good and well ordered fortication, without any of which it can never answer the ends proposed.

The first is, the EXPENCE necessary for the building of it; for should that be greater than the importance of the place requires, it is plain that such a place would be of no advantage.

The second is the NUMBER of troops, to guard and to defend it; for if a place should require so many, as that the expence, together with providing it with artillery, ammunition, and stores, be equal to, or exceed the revenue or advantage arising from such a place, it is manifest, that instead of being any advantage, it would be a disadvantage.

And the third is, the CAPACITY of the town with regard to the space taken up by the fortification; for if it should happen that the town could not contain a sufficient number

of troops to defend it, besides the inhabitants, it is evident that it may be taken with less expence than another of fewer works, provided with the same number of troops; and therefore, such a fortification will not answer the ends proposed in fortifying it; St. *Philip*'s Castle in *Minorca* is an instance of this sort; and such are Mr. *Coehorn*'s systems, as we shall shew hereafter.

If the question was only to fortify a town strongly, without any other considerations, one might make outworks upon outworks without end; but if it is considered, that a whole state might be exhausted in the building of one single fortification, and which would require a whole army to defend it, it will easily appear, that the strength and bigness of a fortified place ought absolutely to depend on the importance it will prove to a nation.

Besides the general considerations, there are several particular ones; which are necessary in the well ordering all the different parts, so as to make the best defence that can be for a place of that expence.

1. There ought to be no part, but what can be seen or defended by some other; which in the phrase of fortification is, all parts

parts ſhould flank each other reciprocally; for flanking or defending is the ſame thing.

For if there is any part that is not ſeen or defended, the enemy might approach that way under cover, and make themſelves maſters of it, without much trouble or loſs.

2. The defence of every part ſhould be always within the reach of muſket-ſhot, ſo as to be defended both by great and ſmall fire arms; for if it be only defended by canon, the enemy may diſmount them by the ſuperiority of theirs, and then the defence would be deſtroyed at once; whereas, if a work is likewiſe defended by ſmall arms, then, if the one is deſtroyed, the other will ſtill ſubſiſt.

3. All the defences ſhould be as nearly direct as poſſible; for it has been found by experience, that the ſoldiers will fire directly before them, without troubling themſelves whether they do execution or not; there are other advantages in a direct defence, as we ſhall prove in the following propoſitions.

4. A fortification ſhould be equally ſtrong on all ſides, otherwiſe the enemy may attack it in the weakeſt part, whereby its ſtrength would become uſeleſs.

In a regular fortification, where all ſides are equally fortified, it cannot happen otherwiſe than to be every where equally ſtrong: but it is not ſo in the irregular, which requires great ſkill and knowledge to make a place ſo; and no author, that I know, has ſhewn how, and in what manner, we are to judge of the ſtrength of the ſeveral parts in ſuch a fortification, although they all agree to the importance of that maxim.

There are commonly ſeveral other maxims given by authors, which, in my opinion, ought rather to be proved, than only aſſerted.

PROPOSITION I.

Of two batteries which have equal fronts, that whoſe fire is direct is the moſt advantageous.

Pl.XVIII. For let AB be an object to be fired at, from the battery CD equal in front; then I ſay, that this battery CD, which is directly oppoſite to AB, is more advantageous than any oblique one, as CL, whatſoever.

For if CD be divided into any number of equal parts, ſuch as ca, ab, &c. and from theſe points perpendiculars are drawn to CD, inter-

interſecting CL, in c, d, &c. then, if each of theſe parts of CD is the ſpace neceſſary for one gun, or for one man; it is evident, that each of the correſponding parts C c, c d, of CL, will likewiſe be neceſſary for one gun or for one man: from whence it reſults, that there can be no more guns or men placed on the oblique battery CL, ſo as to fire at the object AB, than on the direct one CD.

Now becauſe the oblique battery CL is longer, and therefore of more expence than the direct one CD; and as the troops placed on the battery CL, fire with more uncertainty, eſpecially when they are in a hurry and in danger, than if they were placed behind CD, where they only fire directly forward; it evidently follows, that the direct battery CD is more advantageous than any oblique one whatſoever.

N. B. As the parapets are 3 toiſes, or 18 feet thick, it is not only uncertain, that the ſoldiers in a hurry fire at an object obliquely ſituated, but likewiſe very difficult and troubleſome; ſo that beſides the advantage of a direct defence mentioned in the laſt propoſition, this one is as much eſſential as any.

Proposition II.

If the object AB be a counter-battery, the direct battery CD is still preferable to any oblique one CL whatsoever.

Let BE be perpendicular to CL produced; then the force, whereby a cannot-shot from the battery AB would strike the battery CD, is to the force it would strike the oblique battery CL, as BL to BE; or because of the similar triangles BLE, CLD, as CL, to CD; that is reciprocally as the lengths of the batteries.

But the resistances of the batteries are reciprocally as the forces whereby they are struck, and therefore directly as the lengths or expences.

But the resistances of these batteries are only at the beginning, as the expences; for as soon as the least breach is made in the wall, they are nearly equal: besides, if the guns of the battery AB fire directly, as they easily may, except the battery CL is very oblique, the resistances will be equal from the beginning; and as the guns are as easily dismounted on the oblique Battery CL, as on the direct one CD, it evidently follows, that the direct battery CD is more advantageous than the oblique one CL.

Cor.

From whence it follows, 1°. that if the fire from the battery CD is to be directed towards a point A, the battery CD ought to be an arc of a circle, defcribed from that point A, as center. Fig. 2.

2°. And if the fire from the battery CD is to be directed to a line EF, of a greater or leffer extent than the battery, it ought again to be an arc of a circle, fuch that the radii CA, DA, drawn from its extremities, fhall pafs through the extremities E, F, of the object, and make equal angles therewith.

Problem.

To determine the feveral parts of a front of a fortification.

I. It is evident, that every part of the front AEFGHB, difpofed in the manner defcribed before, is feen and defended by fome other part, as well as the ditch before it; for the flank HG, defends the ditch from the perpendicular CD to the face EA produced, as well as that face itfelf; the Fig. 3.

flank

flank EF and half the curtain, and the flank EF defends the other half of the ditch from CD to the face HB produced, that face the flank HG and half the curtain; and conſequently no part of this front can be approached, without being ſeen and defended by ſome other part.

II. The next thing to be conſidered is the length of the lines of defence AG, FB, which ſome will have to be within muſket-ſhot, and others longer; the firſt ſay, that the principal ſtrength of a fortification conſiſts in the uſe of ſmall arms, becauſe the guns fire but ſlowly, are ſoon diſmounted, and require much time to be remounted; whereas the fire from ſmall arms is very briſk, and when one man is killed another takes his place immediately; this is anſwered, that canon does greater execution, and requires much trouble to make an epaulement to reſiſt their force, whereas a moderate epaulement is a ſufficient cover againſt ſmall arms: beſides, when the lines of defence are of a ſufficient length, the ſeveral parts of the fortification become ſpacious and more convenient for placing both more guns and men in them; it alſo obliges the enemy to extend their trenches much farther, than if theſe lines were ſhorter.

But it is evident that, although the lines of defence are within muſket-ſhot, there may be placed both ſo many men and canon as are neceſſary to defend the works; and the works are likewiſe ſpacious enough for all other purpoſes.

From whence it is concluded, that the length of the lines of defence ſhould not exceed the reach of muſket-ſhot, which is commonly obſerved now-a-days; except when the front lies near a great river, and can hardly be attacked on that ſide, there they are often made longer.

It has been found by experience that a common muſket-ſhot will hardly kill a man at a greater diſtance than 160 fathoms Engliſh meaſure; and therefore the lines of defence ought not to exceed that length when the front can be approached.

III. The length of the faces AE, BH, ſhould be ſuch that the flanks are of a ſufficient length, and the gorges of the baſtions not too narrow: they are never made leſs than 50 toiſes, nor greater than 70, in a fortification whoſe exterior ſide is 180 toiſes or upwards.

But as to the length of the perpendicular CD, it is no ways determined; for ſome engi-

engineers make it twice as long as others: they ſeem indeed to differ from one another, merely out of contradiction; ſince none of them, that I know of, has given any reaſons for this practice; although it be plain, that the longer this perpendicular is, the greater the flanks will be; and therefore the defence ſo much the greater likewiſe.

But then the expences increaſe alſo in proportion, and conſequently the length of the perpendicular ſhould be determined according to the expence, which a ſtate will be at, and according to the importance of the place.

IV. The poſition of the flanks is no more certain than the reſt, ſince almoſt all engineers differ from one another in that reſpect; although it is evident that there muſt be a certain and determinate poſition better than any other.

For if their uſe be conſidered, the poſition will eaſily be known, as they are to defend the ditch before them; and it is a received maxim in fortification, that the direct defence is the beſt; and we have proved in the two foregoing propoſitions, that it has ſeveral advantages above an oblique one: it follows from the corollary after theſe propoſitions, that

that the flanks ſhould be an arc of a circle deſcribed from the point of interſection, of the line of defence and oppoſite counterſcarp produced, as center; or becauſe this arc differs but little from its chord; a right line which makes equal angles with the line of defence, and the counterſcarp produced.

Having thus determined the ſeveral parts of a front, we ſhall proceed in our examination of the ſeveral parts of the two foregoing authors fortifications.

Remarks on M. VAUBAN's *firſt method.*

This method is very ſimple, eaſily conſtructed, takes up but little ground, ſince the inward ſpace left for buildings is to the ſpace taken up by the fortification comprehending ravelins and covert-way, as 970 to 1622 nearly; that is, the fortification takes up about one and a half more ground than the buildings; it is free from all ſurprizes, by its ſtone revetements, requires not many men to defend it, by the contiguity of its works; and is of very good defence, eſpecially when ſome outworks are added; ſuch as counterguards before the baſtions, lunettes, or tenaillons to cover and defend the ravelins.

But

But it muſt be confeſſed that his flanks are too ſmall, ſince the enemy can always erect counter-batteries ſuperior to them, as M. *Coeborn* obſerves; (pag. 11. Engliſh edit.) but with regard to the battery, which he pretends to place in the ravelin, it is only a conceit, to impoſe upon the incautious reader; ſince the fire from the whole curtain can always deſtroy that battery, as being much ſuperior to it, and which cannot be ſilenced till the ravelin is taken and a battery erected in it.

The poſition of his flanks come pretty near to the true one, ſince the difference between the angles made by the flank, and the lines of defence, and counterſcarp produced, is but about 2 degrees, which is inconſiderable in practice.

The manner of making retired flanks covered with orillons, is very good; becauſe the flanks cannot be diſcovered by any oblique batteries, and there may be a gun placed behind the orillon, which can be ſeen from no where elſe than from the breach in the oppoſite face of the baſtion.

But for what reaſon he makes his retired flanks to be a circular arc of 60 degrees, is inconceivable to me; ſince flanks are made for no other purpoſes, that I can find, than to

to defend the oppofite ditch; they ought evidently to be fuch arcs as we have demonftrated in the preceding problem, or right lines, which make equal angles with the line of defence and counterfcarp produced. But inftead of defending the ditch directly, they defend all the part of the fortification contained within the angle Q p R, made by the radii n p, m p produced; fo that it feems as if thefe flanks were made quite for other purpofes than to defend the ditch; and what is more furprifing ftill, all modern engineers follow him, as if it were the beft defence which could have been invented; which plainly fhews, when men go upon uncertain principles, how eafily they are led into error. It is true, they imagine to get more room by making this fort of flanks, and that they refift better the fire of the enemy.

But thefe pretended advantages are founded upon as erroneous principles as the reft; for we have proved, that the flank made upon its chord will contain as many guns as that made on the arc itfelf, and refifts better than the curved flank; as is eafily demonftrated by mechanics.

We have fhewn the general ufefulnefs of tenailles, after their conftruction; as likewife their perfections and imperfections.

As

As the ravelins are chiefly made to cover the flanks and curtain, Mr. *Vauban* ought not to terminate their faces on the ſhoulders of the baſtions, but rather 3 or 4 toiſes beyond them: thoſe of the ſecond ſort are ſtill worſe, becauſe their flanks lay the flanks of the baſtions ſtill more open, than the firſt: the third ſort which have redouts within them are the beſt; for they ſecure a retreat to the troops in the ravelin, and the enemy is obliged to raiſe a battery in the ravelin to deſtroy the redout; it takes likewiſe a good deal of ground from the beſiegers, who cannot therefore erect ſuch large batteries in them, againſt the curtain or flanks.

The lunettes are of a very good defence, eſpecially when there is a bonnet to cover the ſaliant angle of the ravelin, as we have mentioned in their conſtruction; the ſame thing may be ſaid in regard to the tenaillons.

Some authors object againſt the lunettes, on account that the ditch, which is defended by the ravelin, has no defence left as ſoon as the ravelin is taken; but as it is hardly poſſible to take the ravelin without being firſt maſter of the lunettes, their objection is of no conſequence; and ſhould the beſiegers be imprudent enough to paſs by the lunettes without

out taking them, they muſt certainly ſuffer much more than if they had.

The counterguards before the ravelins are but ſeldom made; for a redout within the ravelin anſwers the ſame purpoſe and is leſs expenſive: but as to thoſe before the baſtions, they are ſome of the beſt of all outworks, when they are well conſtructed; ſince the enemy cannot pretend to make a breach in the baſtion, nor deſtroy the flanks before they are maſters of the counterguard; and then they have not ſufficient ground to make batteries in them, to deſtroy the flanks and make a breach.

Mr. *Blondel*, and after him Mr. *Coehorn*, make their ramparts ſo narrow, as to leave no room to place guns upon them; and this is to prevent the beſiegers from erecting batteries there, whereby they will be obliged to bring earth from the covert-way, in order to deſtroy the flanks. But as theſe counterguards are only defended in the front by ſmall arms, they can make no great reſiſtance; beſides, the beſiegers may make a few mines under them, and ſo blow up as much as will diſcover the faces and flanks from the covert-way; whereas, if their ramparts are 7 or 8 toiſes broad, they cannot be deſtroyed

by mines; and there will neverthelefs not be fufficient room to erect batteries in them to deftroy the flanks.

I would chufe to make thefe counterguards as high as the baftions themfelves, in order that the enemy might not difcover the baftions but from within the counterguards; by which means the fire of the whole baftion would defend the counterguards in fuch a manner, as to make it almoft impoffible to make any lodgment there.

The horn and crown works are chiefly made, to take away a fpot of ground which might be advantageous to the enemy; to cover the gates of a town, or to build ftore-houfes and hofpitals in them.

The flanks are too fmall as well as the fronts themfelves, and the ditches before the branches are too obliquely defended: the retrenchments made in them are very good, to retire behind when the work is taken, and to difturb the lodgments made there.

Thefe kind of works ought never to be made, but upon the above-mentioned occafions; for their building is very expenfive, and cheaper works would be of a much better defence; notwithftanding M. *Vauban* has too profufely made them, in the fortifica-

tions

tions of *Tournay*, *Ipres*, and in ſeveral other places; and placed them often ſo near each other, as would incline one to believe that he rather intended more to terrify an enemy by their number, than to ſtrengthen the place.

The covert-way ſeems to be of a ſufficient breadth to contain the neceſſary troops to defend them, and the traverſes are abſolutely neceſſary for their defence; contrary to the opinions of Mr. *Coehorn* and others; for without them the covert-way may be enfiladed by the ricochet batteries, from one end to the other: beſides, when the ſaliant angle is attacked, the beſieged have a ſecure retreat behind them; and ſo may be defended to the laſt extremity; experience has ſufficiently proved their uſefulneſs, for at *Liſle* a traverſe was three times taken and retaken.

I am not ignorant that the whole front of the covert-way is ſometimes attacked at once; in ſuch a caſe, the traverſes ſeem to be uſeleſs; but as this only happens when the gariſon is very weak, or the enemy preſumptuous and unſkilful, they generally pay dear for their raſhneſs, and ſeldom can maintain their ground. Beſides, the beſiegers

may drive the troops out of the covert-way with their ricochet batteries, when they are as yet far off, ſo that it is of no manner of uſe after the ſecond or third day of the attack; but to prevent the traverſes being uſeful to the beſiegers in covering them; I would chuſe to make a ſmall mine under them, and when they can no longer be defended, to blow them up.

The arrows and detached redouts are of no great expence; and nevertheleſs, are very good in hindering the enemy from beginning their trenches too near, and to diſturb them in their approaches; but the redouts are liable to be ſurrounded by the trenches and taken by the gorge, if they are not well protected from the covert-way or ſome other outwork; for which reaſon they ſhould never be farther from the covert-way than about 50 toiſes; and if they were mined ſo as to be blown up when they can be no longer defended, they would afford no ſhelter to the enemy when they are taken.

As to the ſecond ditch and covert-way, they being works only made of earth, are of no great expence, and yet may make a very good defence, eſpecially when the ſlope of the firſt glacis goes as low as the ſurface of the water;

or

or when the water can be raiſed in time of a ſiege, ſo as to overflow the beſt part of the firſt glacis; it would oblige the enemies to bring earth from the ſecond glacis to retrench themſelves upon the firſt, which would coſt them a good deal of time and trouble; and as this muſt be done under the grazing fire of the covert-way, it could not be done without much coſt and danger: the ſecond covert-way ſhould be not above a foot above the ſurface of the water in the ditch, to oblige the enemy to bring earth for making their trenches in it.

M. *Vauban* was ſo ſenſible of the goodneſs of theſe works, that he never failed to make them where-ever he found the ground convenient for it; as may be ſeen at *Sarre Louis*, at the city of *Lille*, and in other places.

Remarks on M. VAUBAN'S *ſecond and third methods.*

The deſign of the ſecond method is, to fortify an old town already incloſed by a rampart; and it is for that reaſon, that he begins within and fortifies outwards, contrary to his other methods, as being more convenient in this caſe: the tower-baſtions are joined to the

old wall, and have underneath a magazine in the form of a croſs; all round this magazine are caſemats, or cellars to hold both men and guns; thoſe in the flanks have each an embraſure which opens into the ditch, and thoſe in the faces have embraſures ſo as to fire out of one into the other when taken by the enemy; and above is a parapet of 12 feet thick with embraſures, as may be ſeen in plate XI, where a plan and ſection of a tower-baſtion is repreſented.

As theſe towers are almoſt a ſolid bulk of maſonry; they muſt be of great expence, though their reſiſtance can be but little; for it has been found by experience, that the caſemats are but of little uſe, becauſe as ſoon as they have fired once or twice, the ſmoak will oblige the defenders to leave them, notwithſtanding their ſmoak-holes.

In my opinion, inſtead of attacking the towers themſelves, the rampart near the flanks of the counterguards may be attacked; and then the flanks of the towers may be deſtroyed by the guns placed on the flanks oppoſite to them, which are already made for that purpoſe, and want nothing elſe but embraſures.

It

It may be concluded, that the ſtrength of theſe towers does by no means anſwer their expences; and that if ſmall baſtions were made inſtead of them, without caſemats, they would be much better and of leſs expence.

As to the counterguards they are very good, and may be defended to the utmoſt extremity without expoſing the town to be taken by ſtorm; but their flanks are too ſmall, and are eaſily deſtroyed from the oppoſite covert-way; there ſhould either be two, or if but one it ſhould be pretty large.

M. *Vauban* conſidering, that as ſoon as a breach was made in the faces of the baſtions, and the paſſage over the ditch finiſhed, the gariſon is always obliged to capitulate, whereby the little defence they make by no means anſwers the great expence in conſtructing them, rightly judged, that if they were detached, it would be much better; for by this means they may be defended inch by inch to the very laſt, without expoſing the town.

For theſe reaſons M. *Vauban* invented his third method; but as it differs only from the former, in having two ſmall flanks in each curtain of about 4 toiſes, which can

hardly hold two guns each; and therefore add no great ſtrength, the ſame exception which we made againſt the ſecond method, may be made likewiſe againſt this.

Remarks on M. Coehorn*'s firſt method.*

Before we enter into any particulars of this method, it is neceſſary the reader ſhould know, that M. *Coehorn* wrote his book before he had acquired that great experience, for which he has been ſo juſtly eſteemed one of the greateſt engineers that ever was, in order that they may not be miſled by the exceſſive praiſes beſtowed by ſome authors, on account of his works which are publiſhed, altho' impracticable in themſelves, and undoubtedly thought ſo by M. *Coehorn* himſelf, after he was a better judge of fortification, as evidently appears by the towns he fortified afterwards; for if he had thought that his works could really make that prodigious defence, which he pretends in his writings, it would be very ſtrange, that he ſhould not have made uſe of them, when he had an opportunity to do it.

Having

Having thus ſhewn in general, that the author himſelf diſapproved his works; we ſhall now proceed to ſhew the advantages and diſadvantages of the particular parts.

We ſhall begin, with ſhewing that the expence which he pretends to be much leſs in the building of this fortification, than that of the French method, is not ſo inconſiderable as he fain would perſuade the world: firſt the room within for buildings, is to that taken up by the fortification as one to three nearly, rather more than leſs; and as he makes his inward polygon equal to that of M. *Vauban*'s exagon; and we have found, that the inward polygon is to the ſpace taken up by the fortification as unity, to $1\frac{1}{2}$; the fortification of M. *Coehorn*'s method takes up juſt as much ground as that of M. *Vauban*, and therefore double the expence for removing the earth; but then he ſays, that much leſs maſonry is required here than there, and it is upon this he grounds his frugality; but it has been found by experience that works of earth coſt as much in time, as thoſe made of ſtone, on account of their continual repairing; ſo that in the whole it appears, that M. *Coehorn*'s exagon coſts more, or at leaſt as much as M. *Vauban*'s exagon:

exagon : then if we consider the lowness of these works, and how easily they may be surprised; they will require at least three times the number of troops and ammunition to defend them, as the French one.

For when a place is out of danger from being surprised, there requires but a few troops to guard the works which are not attacked; whereas on the contrary, the others must be every where equally guarded; otherwise the besiegers may make a sham attack on one side to draw the besieged that way, and surprise some of the works on some other side.

The next thing is to examine, whether the different works are constructed in the best manner: first, as to the upper and mean flanks, they seem to be the only thing the author borrowed from the *French*, and is just the worst of all M. *Vauban*'s works, as we have shewn heretofore: the curtain of the tenaille would have been better straight than crooked; the towers being but small and a parapet quite round them, are very dangerous, and a fair mark for throwing shells, by which there is no security for those within: the dry ditches and lower faces of the bastions and ravelin are easily enfiladed by the ricochet batteries;

and the paliſſades placed in them, to ſecure a ſafe retreat, are very dangerous; becauſe if a ſhot hits them, the ſplinters will do more miſchief than the ſhot itſelf; as to the caſemats in the towers, they are very bad, as we have ſhewn before, ſpeaking of the tower-baſtions; the ſtone galleries made under the ramparts of the lower faces of the baſtions and ravelins, ſeem to be uſeleſs on account of the ſmoak, for the ſame reaſon as all caſemats are; and if ſome grenadiers go between the loop-holes and fling a few grenades into them, they muſt infallibly deſtroy thoſe within.

The redout in the gorge of the ravelin is of excellent uſe to ſecure a ſafe retreat to the beſieged, which is in my opinion of the greateſt conſequence; for if the troops have no retreat, they can never defend a work ſo well as they might do otherwiſe.

The wet ditch before the lodgment and the dry ditch of the ravelin, are in a wrong place, ſince they are directly oppoſite to the ditch before the counterguards; and theſe lodgments themſelves being only a ſtone wall, are eaſily deſtroyed by the ricochet batteries.

The

The rampart of the counterguards being only 28 feet broad including the parapet, they are easily destroyed by mines, as we have mentioned before speaking of counterguards; no canon can be placed in them; neither are their ditches defended by canon, except from the higher faces of the ravelin; and as to the covert-way, it is by much too spacious, and liable to be enfiladed from the beginning of the siege, by the ricochet batteries placed before the first parallel; so that of this spacious work, there are only the places of arms which can make a defence; the redouts in the places of arms being inclosed quite round, are dangerous to defend, for a few shells thrown into them must inevitably destroy those within, or oblige them to quit the work; and they are contrary to the general maxim of fortification, that no part whatsoever should be so as not to be seen or flanked by some other; but here, if the enemy gets once possession of these redouts, the walls near the counterscarp will cover them in such a manner, as not to be seen from any part of the fortification.

As to the coffers lodged in the glacis, they cannot much retard the approaches of the enemy, being only defended by small

arms;

arms; ſo that a few gabions filled with earth, will eaſily cover the beſiegers againſt the fire of theſe works.

It is moſt certain that when M. *Coehorn* publiſhed his book, he knew nothing of the ricochet firing, the invention of which being of later date; and therefore was not aware of the inconveniences which attend now-a-days theſe low works; otherwiſe he would never have made uſe of them; and it is undoubtedly for this reaſon, that he never put them in practice afterwards, when he was acquainted with this manner of firing; the manner of fortifying of *Bergen-opzoom*, differs ſo little from M. *Vauban*'s firſt method with orillons, that I took it for the very ſame till I was better informed; and this place is undoubtedly a maſter-piece of art.

The comparing of this method with the *French* exagon, fortified with ravelin and covert-way only, is not juſt; for the one takes up twice as much ground, and requires about three times more troops to defend it than the other, and therefore there ought to be no more compariſon between them, than there is between a place of few works, and another of a great many; but to make the compariſon right, the author

ſhould have compared his exagon with a *French* one of an equal number of works.

M. *Coehorn*'s ſecond and third methods are abſolutely impracticable; for their fortification takes up five times as much ground as the town; and therefore, the town would hardly hold more people, than the number of troops required to defend the fortification, beſides the ſtore-houſes for the prodigious number of artillery and ſtores.

Having thus finiſhed our examination of the methods of the two moſt celebrated authors, we ſhall now proceed to ſhew in what manner the ſeveral parts of the body of the place are to be conſtructed, ſo as to be capable of the beſt defence, proportionably to the expence.

A new Conſtruction.

Pl. XV. Fig. 3. Let AB be the exterior ſide of any length, ſuppoſe 180 toiſes; make the perpendicular CD of any length, as the 6th, 5th, or 4th part of the exterior ſide, according to the expence or importance of the place: here it is the 6th part or 30 toiſes; ſet off 50 toiſes or more for the faces BH, AE, or rather $\frac{2}{7}$ of the exterior ſide; from the ſaliant

saliant angle A describe an arc with the radius A I of 2 or 3 toises more than the breadth of the ditch; draw from the opposite shoulder H a tangent H I to that arc, and from the angle A the indefinite line A b parallel to that tangent; then if from the angle A as center an arc a b be described with any radius, the flank G H is drawn parallel to the chord a b: one of the flanks being thus found, the others will be found by taking the distance D G, between the perpendicular and the angle of the flank, and carrying it from the extremities of all the perpendiculars on the lines of defence, as from D to F; this being done, the counterscarp of the ditch is drawn parallel to the line HI or to A b; and having the point or re-entring angle O, its distance from the extremity of the perpendicular, being carried all round, will give the re-entring angles before the other fronts.

The tenailles h k, which M. *Belidor* has invented, and called them *Rams-horns*, are described, by setting off 3 toises from the shoulder of the bastion to the point h, and drawing h f perpendicular to the line of defence; then its intersection f, with the other line of defence produced, will be the center of the arc h k.

To

To conſtruct the Ravelin.

Set off 12 or 15 toiſes from the ſhoulder E to the point r, in the face of the baſtion, and from the angle G of the flank as center, deſcribe an arc through the point r, meeting the perpendicular C D produced at L; from this point L draw the faces, ſo as when produced to fall on the faces of the baſtions within 3 toiſes of the ſhoulders; the ditch of the ravelin is 12 toiſes.

To conſtruct Retired Flanks.

Find the flank QR as before, on which ſet off 5 or 6 toiſes for the ſhoulder or orillons; and from a point g in the oppoſite face of the baſtion at 5 toiſes from the ſaliant angle B, draw the broken part of the flank; then draw the retired flank parallel to the line QR, at 5 toiſes diſtant from it: the orillon may be made round in the manner of M. *Vauban*'s, if it be thought proper.

Remarks on this conſtruction.

This conſtruction is general, let the exterior ſide A B be what it will; the flanks make equal angles with the lines of defence and the counterſcarp produced, and therefore defend the ditch in the moſt direct manner; the counterſcarp terminates at the inner angle of the ſhoulder, ſo that the gun placed in that angle grazes all along the counterſcarp: the ravelin is of a due proportion, its ſaliant angle is neither too narrow nor too open, and its faces cover the flank of the baſtions ſufficiently from being ſeen obliquely.

The orillons are made 5 toiſes long only, which appears to me ſufficient for covering the retired flanks, and by making them ſo, the flanks are larger than if they were made 9 toiſes, as M. *Vauban*'s: the rams-horns have ſeveral advantages over the common tenailles, they cannot be enfiladed, leave more room between them and the flanks, ſo that the rubbiſh from the flanks do not incommode the troops in the rams-horns; and being circular they ſee not only the ditch directly, but likewiſe the level ground of the

ravelins, and the oppoſite covert-way; they alſo reſiſt the oppoſite batteries much better, and are of leſs expence in their conſtruction, and therefore preferable in all reſpects to the common tenailles.

If theſe flanks are not thought ſufficient, another might be made behind them, in any polygon above an exagon, without making the gorges of the baſtions too narrow; there might even be made another in an exagon, provided the firſt be only 20 feet retired, and this would be ſufficient to cover it.

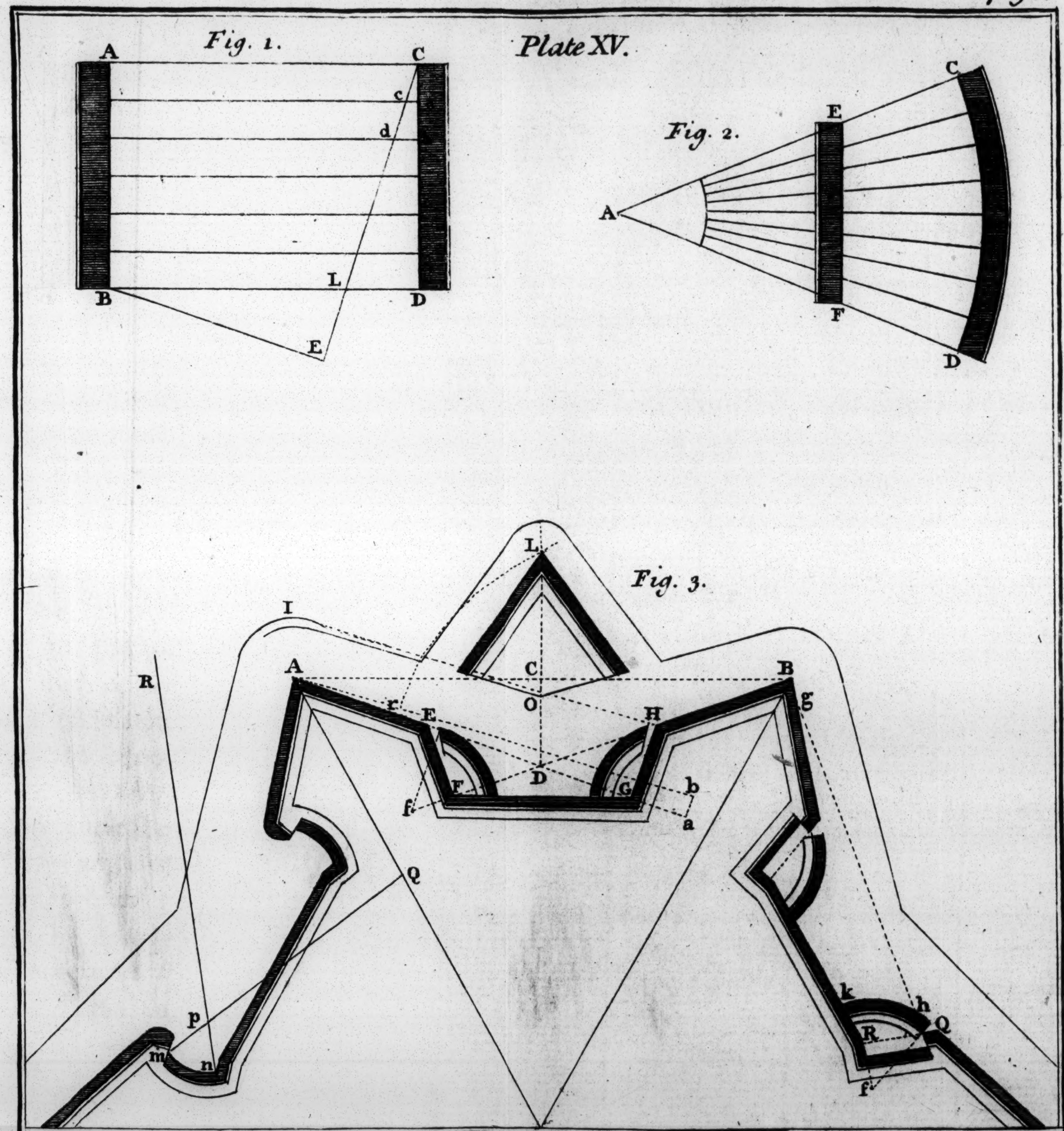
To conſtruct Horn and Crown-works.

When there is a neceſſity to conſtruct horn or crown-works, either to cover a gate or to occupy a ſpot of ground which migh[t] be advantageous to the beſiegers, and whic[h] can no other ways be taken into the fortifica-

Pl. XVI. fig. 1. tion; then the diſtance AD from the front [of] the horn-work to the ſaliant angle A, of th[e] ravelin or baſtion, ſhould not exceed 10[0] toiſes, otherwiſe the branches cannot be w[ell] defended by the oppoſite faces of the baſtio[ns] or ravelins; they ſhould only be about [...] as in this figure, if it may be done; [...]

fr[...]

Plate XV.



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front EDF, 120; the perpendicular DC one fifth part of the exterior ſide, that is 24, and the faces 30; and ſo in proportion to the exterior ſide: the arc deſcribed, for finding the poſition of the retired flanks, ſhould have a radius of 18 toiſes; that the counterſcarp of the ditch may terminate at the extremity of the orillon, which is but 5 toiſes long, the flanks are as much retired, and made in the ſame manner as thoſe in the body of the place: we have added rams-horns inſtead of tenailles, in order to get as much flank as could be.

The branches of the horn-work terminate on the faces of the baſtions within 30 toiſes of the ſhoulders, the ditch is 12 toiſes, the parapet of the horn-work is 12 feet high, as well as that of the ravelin which is conſtructed in the manner deſcribed before; that is, by deſcribing an arc from the angle of the flank, through a point in the faces of the horn-work, 12 toiſes diſtant from the ſhoulder, whoſe interſection with the perpendicular CD produced, will give the ſaliant angle of the ravelin; the faces terminate within 3 toiſes of the ſhoulder; the ditch of the ravalin is but 8 toiſes; the retrenchments S are conſtructed by producing the branches,

 and

and the counterſcarp of the ditch before the ravelin, till they meet; and by ſetting off 25 toiſes on that counterſcarp, for the firſt, and 20 more for the ſecond; then if from the point O as center, arcs are deſcribed through theſe points, which meeting the branches, will give the other points through which the retrenchments paſs; they are made of earth only, their parapets ſhould be but 9 feet higher than the level ground, with a berm of 6 or 8 feet, and a dry ditch of 4 toiſes before them.

The diſtance A B or radius of the arc, which paſſes through the points C, B, D, of the crown-work is 100 toiſes, and ſhould not exceed 120 or 130 at moſt; the exterior ſides BC, BD, are 100 likewiſe; the perpendiculars 20, that is, one fifth of the exterior ſides; the faces 26; the radius of the arc which ſerves to determine the poſition of the flanks is 15, and the ditch 12; the branches terminate on the faces of the baſtions within 30 toiſes of the ſhoulders, in the ſame manner as thoſe of the horn-work; the ravelins are conſtructed in like manner as in the horn-work; as likewiſe the retrenchments S, except that the firſt is only 20 toiſes from the great ditch.

Fig. 2.

Remarks

Remarks on this construction.

The branches of these works are more directly defended by the faces of the bastions, than those which are usually made; the flanks much larger and covered by the orillons, and the rams-horns added to the flanks, make together a larger battery than can be erected against them, which is a maxim in fortification, to be observed, if possible; otherwise the flanks are soon destroyed, the faces become defenceless, and so the work may easily be taken.

It is to be observed, that there should be a row of palissades placed in the middle of the dry ditches before the retrenchments S, and the parapets of these retrenchments should be fraised likewise; that is, there should be a row of palissades placed about 3 feet above the berm horizontally, or rather with the points a little downwards, that the grenades may roll off into the ditch.

For, if this precaution is not taken, the enemy might persue and follow the troops which defend these works, so as to enter with them into the retrenchments, and thereby

by get maſters of them at the ſame time the hornwork is taken.

The reader will eaſily imagine, that there muſt be a barrier or gate in the ditch near the branches of the horn or crown-work; as likewiſe a ſally port under the parapets, for the troops to retire through, when the work is taken.

Conſtruction of a place with Detached Baſtions.

As a gariſon ſeldom or never ſuffers the enemy to make an aſſault on the baſtions when they are joined to the place for fear of being put to the ſword, and the town ſacked, the baſtions are never capable of making a defence anſwerable to the expence of building them; it cannot therefore be ſaid, that ſuch a place anſwers the intent for which it was fortified.

It was for this reaſon, that M. *Vauban* invented his ſecond and third methods, as we have already mentioned in their conſtruction: but as his tower baſtions will hardly anſwer the great expence of their building, we thought it would not be improper to propoſe two methods, of the ſame

nature,

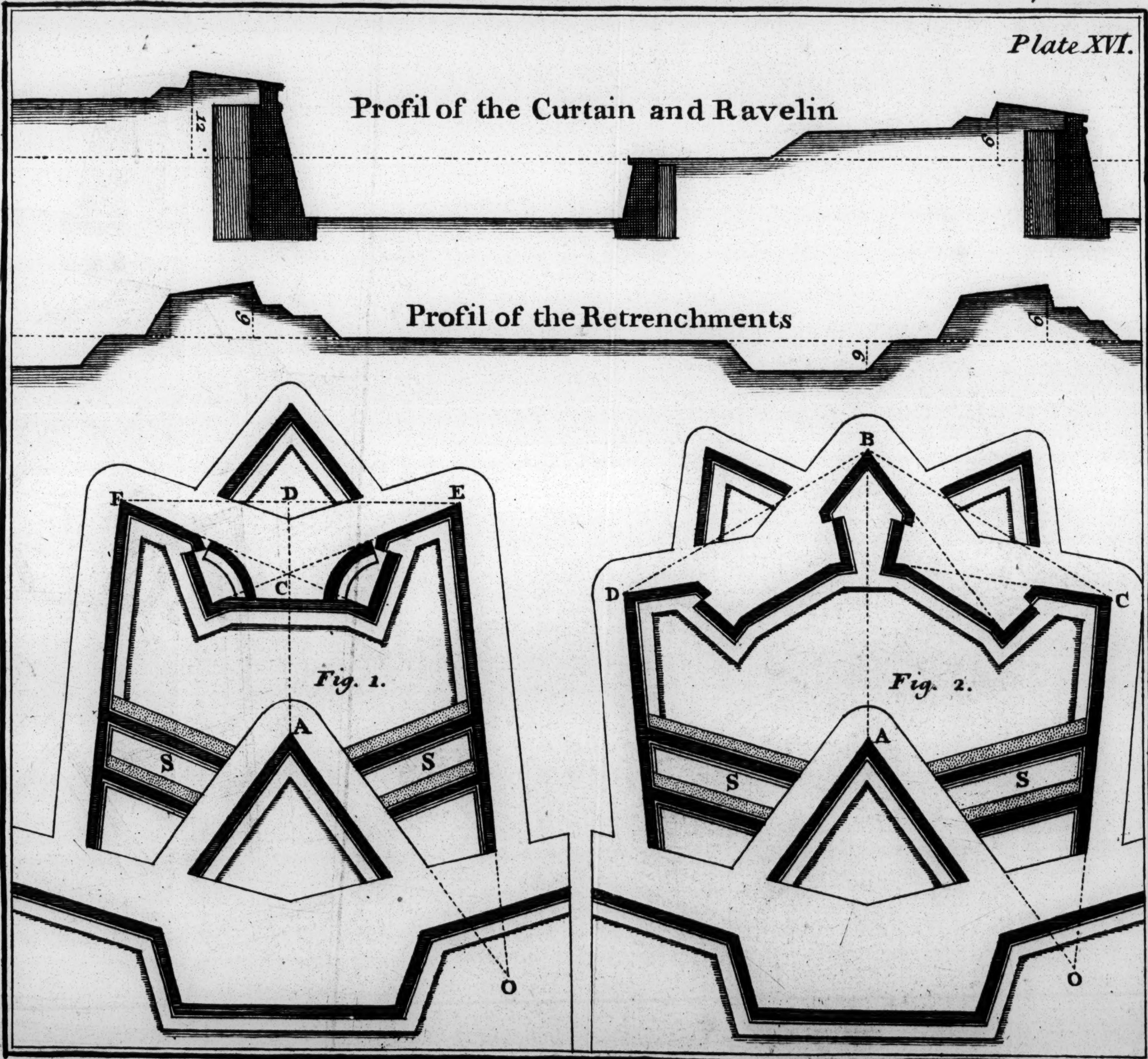
Plate XVI.
Profil of the Curtain and Ravelin
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Profil of the Retrenchments
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Fig. 1.
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nature, in which it has been endeavoured to make every part anſwerable to the expence of building them; as likewiſe to diſpoſe them in ſuch a manner, as to make the beſt defence that they will admit of.

Let the interior ſide AB of an octagon be 120 toiſes; take Ab, Bn, equal to 12 toiſes for the ſemi-gorges of the ſmall baſtions, and as much for their capitals Ac, Br; from the points c, r, draw the lines cn, rb to the extremity of the gorges, and make the flanks bd, nm perpendicular to the lines of defence; the ditch is 6 toiſes at the ſaliant angles c, r, and its counterſcarp drawn to the extremities of the flanks of the detached baſtions. P. XVII.

The capitals cC, rD of the detached baſtions are 55 toiſes, and the lines of defence are drawn to the extremities b and n of the interior flanks; the faces are 60; the radius of the arc which ſerves to determine the poſition of the flanks 18, and the ditch 16 at the ſaliant angle.

The ravelin is conſtructed by deſcribing an arc from the extremity of the flank, as center, through a point in the oppoſite face of the baſtion, within 20 toiſes of the ſhoulder, which arc interſects the capital of the

ravelin at the ſaliant angle; the faces terminate within 5 toiſes of the ſhoulders, the ſemi-gorge of the redout R is 15, its faces parallel to thoſe of the ravelin, and its parapet 2 toiſes; the ditch of the ravelin 12, and that of the redout 6.

The ſemi-gorges of the places of arms are 20 toiſes, thoſe of the ſtone redouts p within them 12; the faces of the places of arms are 25; and, thoſe of the redouts parallel to them, with a dry ditch of 3 toiſes before them; the covert-way is 6, and the glacis 20.

The faces of the tenailles are 16 toiſes, the paſſage between them and the flanks of the baſtions 3; their flanks are parallel to the others, and the curtain is drawn through the points where they meet the lines of defence, and the inſide of the tenailles is terminated by lines drawn through the extremities of the flanks.

Remarks on this conſtruction.

This method anſwers perfectly the intent for which M. *Vauban* has invented his ſecond and third methods; for the ſmall baſtions are more extenſive than the tower baſtions, and

and yet coſt much leſs in their conſtruction; the tenailles adding a lower flank to that of the detached baſtions, renders their fire ſuperior to that of the beſiegers; and to ſecure the lower flanks from the enfilades, a part of the faces next to the ſhoulders, ſhould be raiſed about 3 feet higher than the reſt, for the ſpace of 4 or 5 toiſes.

The town wall ſhould be of the ſame height and no more, than the detached baſtions and ravelin; for which reaſon we made them all 15 feet high, the tenailles 3, and the ditches 12 feet deep; and if the works were only 12 feet high it would be ſufficient.

It is the opinion of ſome modern engineers, that if all the works were of the ſame height, it would be much better, than to make the inner ones ſo as to exceed thoſe before them by 8, 10, 12 feet, as is cuſtomary.

For it is evident, that thoſe high walls encreaſe the expence prodigiouſly, and may be battered at a great diſtance; ſo that before the enemy have carried their approaches near the place, all the defences are ruined; which will not happen, if a work cannot be diſcovered till that which is before it is taken.

It is ſaid, that when the works exceed each other in height, the enemy can be fired at from all of them at once; but this is a great miſtake, for they may raiſe batteries at 300 toiſes diſtance from the place, and from thence diſmount all the guns; which being continually kept playing, will prevent the gariſon from erecting new batteries; and the guns being once diſmounted, the fire of the ſmall arms can produce no great effect againſt the trenches.

Inſtead of which I would chuſe to place guns in the places of arms, and keep them there till ſuch time that the covert-way is in danger of being attacked; and then remove them into the inner works, and ſo from one to another, till into the body of the place; for if the guns in the baſtions, or counterguards and ravelin are not diſmounted till ſuch time the covert-way is attacked, it will be a difficult matter to get and remain in poſſeſſion of it.

All the objection that can be made againſt low walls, is that they are eaſily enfiladed by the ricochet batteries; to avoid which, the ſaliant angles of all the works ſhould be raiſed about 4 feet above the other parts, for the ſpace of 5 or 6 toiſes on each ſide; and the rampart ſhould likewiſe ſlope towards the

the place by 2 or 3 feet, which has been done by M. *Vauban* at *New Brisach*, and by M. *Coehorn* at *Bergen-opzoom*; which being the last places that these great men have fortified, is sufficient to determine others to follow their examples.

The redout p in the place of arms, should be a wall of 3 feet thick only with loopholes, and no higher than the glacis, or rather two feet lower, so that they cannot be discovered but from the ridge of the glacis; the inside of them may be 2 or 3 feet lower than the rest of the covert-way, and so as to slope towards the ditch, that if any grenades or shells should fall into them, they might roll into the ditch.

The redouts R in the ravelin ought to have a parapet of 12 feet thick only, as being sufficient to oblige the enemy to raise a battery in the ravelin to destroy it, which is all that is wanted; they serve to retire into when the ravelin is taken, and obstruct the lodgments there; from whence the troops may retire into the body of the place, when they can hold out no longer.

As to the flanks they are so disposed as to defend the ditch in the best manner possible, and since the detached bastions are wide and spacious,

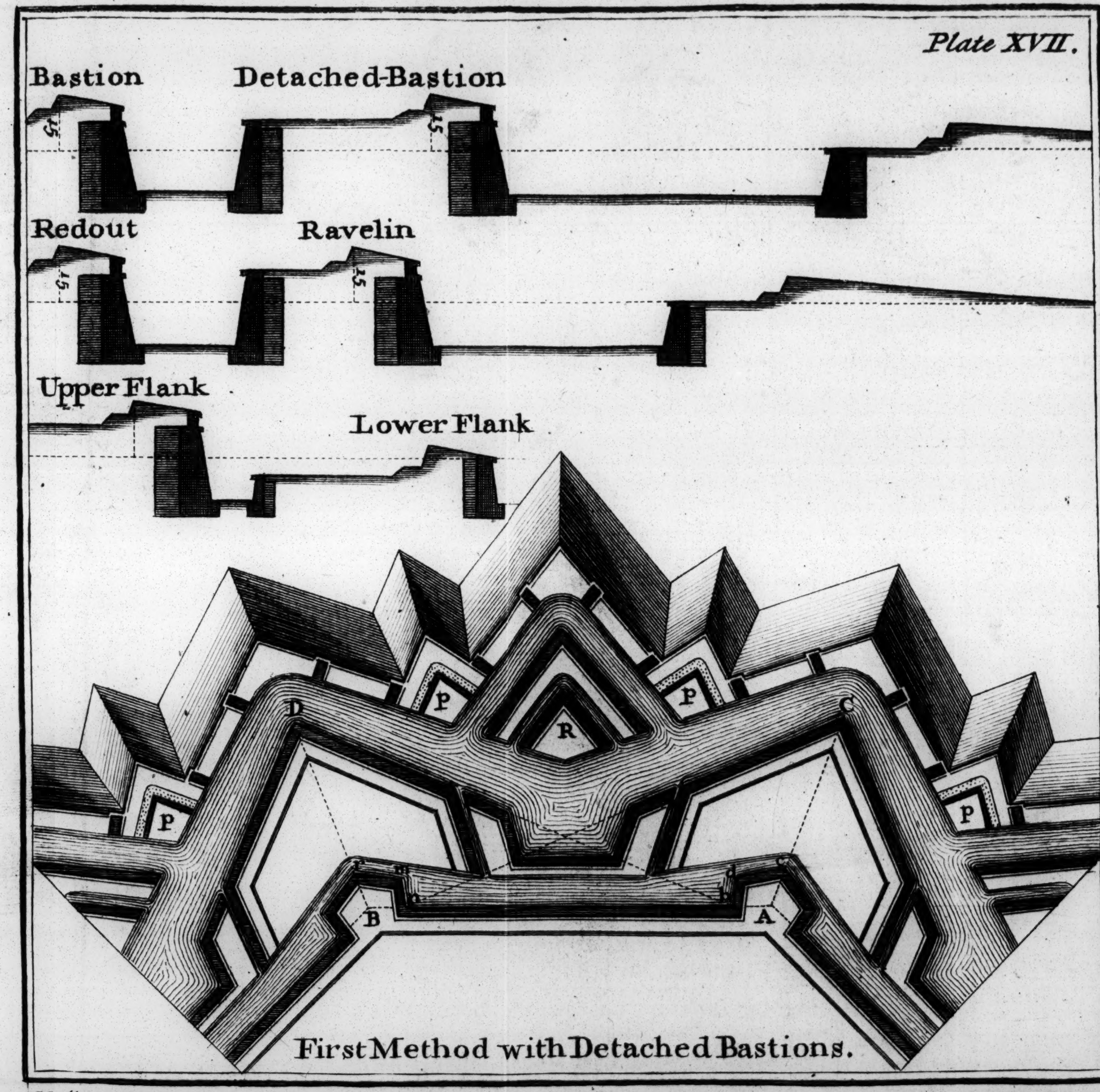
ſpacious, a third flank may be added, if it is thought neceſſary.

Conſtruction of a place with detached Orillon Baſtions.

Pl.XVIII. Let the exterior ſide AB of an octagon be 200 toiſes, the perpendicular CD 40, that is, a fifth part of the exterior ſide, the faces AE, BF, 55; the radius of the arc which ſerves to determine the poſition of the flanks 22; the ditch 16 at the ſaliant angles; the orillon 5; the flank is retired 5 toiſes; and the line k d which terminates the flanks is drawn from a point d, in the face at 5 toiſes from the ſaliant angle; the ſhoulders of the tenailles are 20 toiſes from thoſe of the baſtions; the flanks parallel to the others, and the curtain is drawn through the points of interſection of the flanks and lines of defence.

Take on the lines E l, F h, drawn from the extremities of the faces parallel to the flanks, and which terminate the inſide of the tenailles, the parts l n, h m, each of 6 toiſes, for the breadth of the ditch; and upon the exterior ſide r n, conſtruct a front of a polygon, by making the perpendicular 12, and faces 20 toiſes.

The



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The redouts V are made of a wall 3 feet thick only with loop-holes, their ſaliant angle is determined by the counterſcarps of the inner ditch produced; and the faces terminate within three toiſes of the ſhoulders, the ditch about theſe redouts is 4 toiſes.

The ravelins and covert-way are conſtructed in the ſame manner as thoſe in the former method.

Remarks.

This method being more expenſive than the former, has the advantage in proportion; the ditch is defended by large double flanks, which will hold more guns than the enemy can oppoſe; for we ſuppoſe the body of the place and the detached baſtions to be but 3 feet higher than the glacis, that is 10 feet above the level; ſo that the flanks cannot be diſcovered but from the ridge of the glacis; the redouts V, are of ſpecial uſe to retire into when the detached baſtions are taken, and to obſtruct the lodgments there; and as the communication from theſe redouts into the body of the place cannot be ſeen from any part, this ſafe retreat is of great advantage; for by this means, the troops will be

be able to maintain their ground to the laſt extremities; neither can the flanks of the inner front be diſcovered but from the level ground of the tenailles, which therefore I would make but a foot above the water in the ditch, ſo that there will not be a ſufficient quantity of earth to raiſe a battery.

If the flanks and faces of the tenailles were arched and open behind, it would be much better, for by that means the enfilading them would be impoſſible, neither would the ſhells have any effect upon them; and then the upper flanks might be made two or three feet lower than the faces, which would prevent the enfilading them by the ricochet batteries; but if this ſhould be thought too expenſive, I would make the upper flank 7 feet above the level, that is, 2 feet lower than the faces, and the lower one even with the level; but then the faces of the tenailles muſt be 4 feet higher than the flanks, to cover them from the enfilades: for it is of the greateſt importance to prevent the enfilading the works as much as poſſible, ſince it is much more dangerous than to be ſeen in the front, and it is too dangerous to defend ſuch a work: this and the ſecuring the retreats, from one work into another,

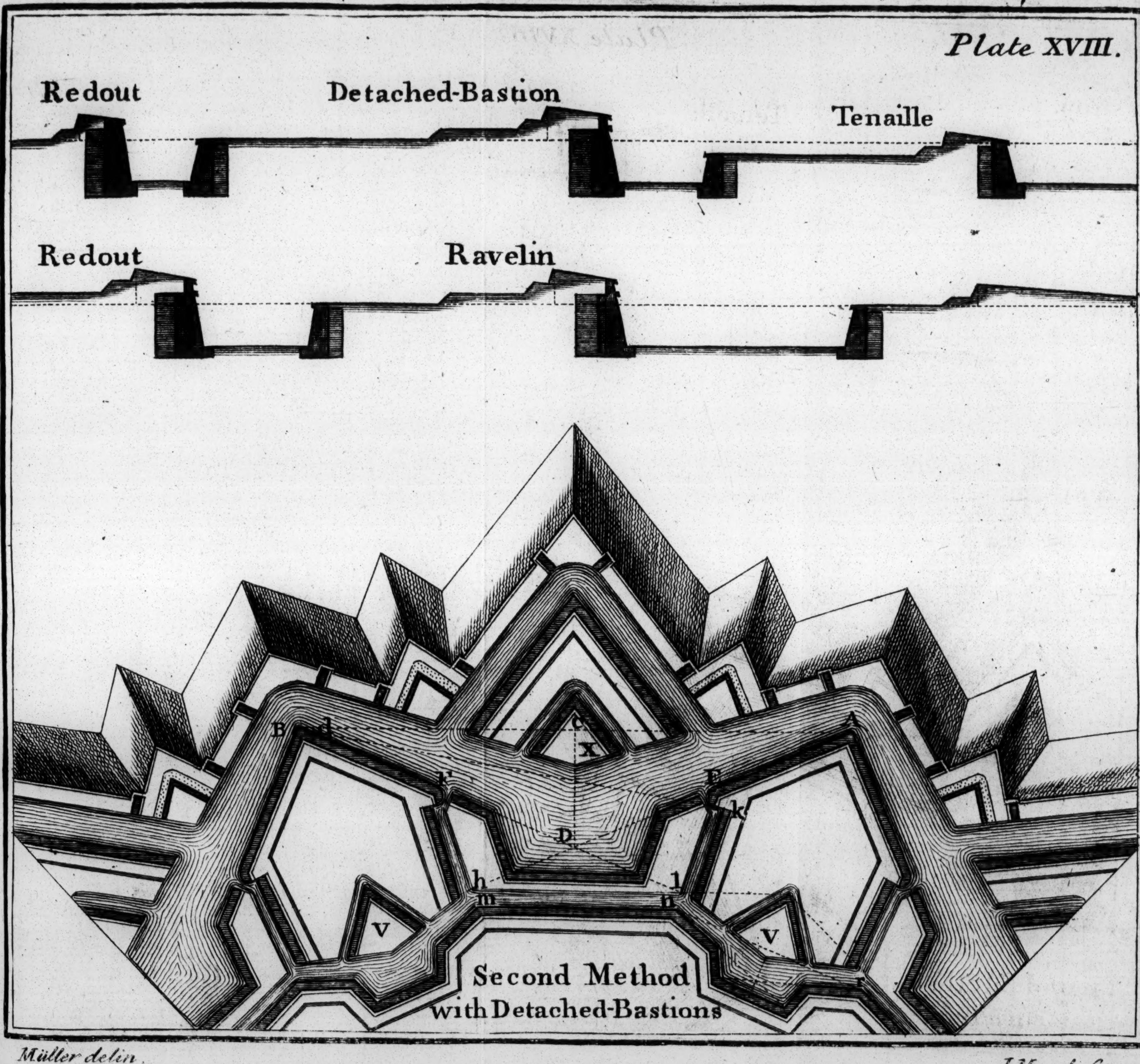
Plate XVIII.
Redout
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Tenaille
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Second Method
with Detached-Bastions
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J. Mynde sc.

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another, are the two greateſt advantages to be gained in a good fortification; and for which the ſtone redouts in the places of arms, in the detached baſtions, and thoſe in the ravelins are all that can be done; for when thoſe works can be no longer defended, the beſieged watch their opportunity in the dark, or when the enemy's fire ſlackens, to croſs the ditch and retire; for it would be imprudent to defend them to the laſt; and there ſhould be mines to blow them up, when they can be of no further uſe.

Conſtruction of a Place with Lunettes and Counterguards.

This figure is an octagon, whoſe exterior ſide is 200 toiſes, the perpendicular 30, and the faces 55; the radius of the are which terminates the poſition of the flanks is 20 toiſes, the orillons are 5; the firſt flank is 5 toiſes retired, and the ſecond 10 from outline to outline; the rampart of the lower flank is 4, and the ditch behind it 3; the faces are 4 feet higher at the ſaliant angles and three at the ſhoulders, than the flanks and curtain, and that exceſs ſhould be of turf: the ditch is Pl. XIX.

 drawn

drawn from the extremities of the orillon parallel to the line which ſerves to determine the poſition of the flanks; the tenailles or rams-horns m, are deſcribed from the point of interſection, of the line of defence produced, and a perpendicular to the faces produced 3 toiſes; and they are terminated by a line 3 toiſes diſtance from, and drawn parallel to the curtains.

The ſemi-gorges of the ravelins R are 20 toiſes, their capitals 30, and the ditch before them 6.

The ſemi-gorges of the lunettes, n, the one is 15, and the other 30 toiſes; and the faces are drawn perpendicular to thoſe of the ravelin and the baſtions, the ditches before them are 8 toiſes.

The counterguards *a* are 7 toiſes broad at their extremities, and the faces perpendicular to thoſe of the lunettes, or parallel to thoſe of the baſtions: the ditch before them is 10 toiſes.

The bonnet b before the ravelin is 10 toiſes broad at the ends, and its faces are parallel to thoſe of the ravelin, or perpendicular to thoſe of the lunette: the ditch before this work is 10, the covert-way 6, and the glacis 20; the places of arms r, are found by

by ſetting off 20 toiſes one way, and the perpendicular drawn thro' that point, meeting the face of the lunettes produced.

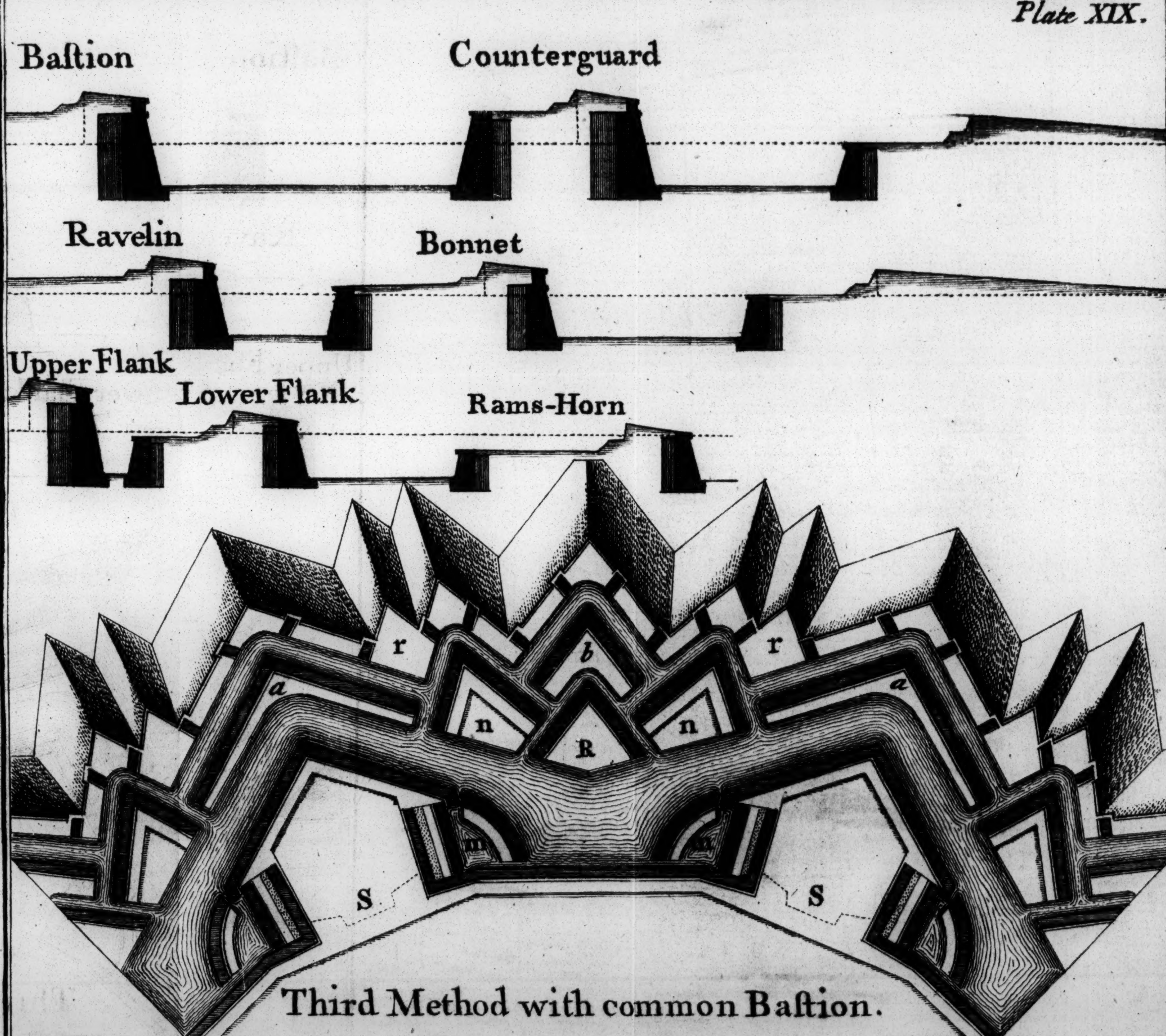
Remarks on this conſtruction.

As all the defences of this place are direct, that of the ravelin excepted, the works will be in a condition of making as great a reſiſtance as can be expected; the curtain, ravelin, lunettes, and bonnet, ſhould be all of the ſame height; as likewiſe the counterguards and baſtions, ſo that the baſtions may not be ſeen but from the counterguards, where there is not ſufficient room for making batteries to deſtroy the flanks; the ramshorns ſerve to ſally out into the ditch, when dry, or to harbour boats behind them when wet; their level ground ſhould not be above 4 or 5 inches above water, or even with the bottom of the ditch when dry; and as they cannot be enfiladed from any part, their grazing fire will extremely well defend the great ditch, and that before the ravelin; as likewiſe the level ground of the ravelin, lunettes, and counterguards.

Although theſe baſtions are of as great a defence as poſſible, yet the enemy will in

time be able to ruin the flanks, and make breaches in the faces; and this being once accomplished, the garison will be obliged to surrender, unless some other defence be found; for which reason, good retrenchments, such as marked S, should be partly made, either at the same time that the place is built, or in time of peace, with a good strong wall and a ditch before it; as likewise with countermines under them, to prevent the enemy from blowing them up with their mines; and from the bottom of this ditch, galleries might be carried on under any part of the bastion, to blow it up, when it can be defended no longer above ground: I said that these retrenchments should only be partly made; because, there must be about 4 toises left unfinished at each end near the flanks, in order that there may be sufficient room behind the flanks to place canon; and when the attack is once made, the parts next to the flanks, which are of no use, may then be finished, and the other afterwards, when the flanks are of no further use: by this means the bastions will be able to make as great a defence, as if they were detached.

Plate XIX.



Third Method with common Bastion.

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For it is in vain to pretend that a place ſhould make a long and ſtout defence, tho' ever ſo well fortified, if the governor either wants means, or does not know how to defend it; and there ought not to be a ſingle work but what ſhould be defended inch by inch, and when the works are ſpacious enough to admit of retrenchments, there ſhould be as many made as can be done; the works muſt not only be thus diſputed above ground, but likewiſe under ground; for all the parts where the enemy is likely or muſt make lodgments ſhould be countermined, in order to blow them up when they can be no longer maintained above ground.

The expence of making countermines and retrenchments is inconſiderable, in reſpect to that of building the fortification, and yet they may lengthen the defence conſiderably. It appears ſhameful, that as ſoon as a breach is made in the baſtion, and often not wide enough to make an aſſault, the gariſon ſhould be obliged to capitulate; it ſeems that the baſtions, which are the moſt conſiderable part of a fortification, and coſt moſt, ſhould ſerve more as a ſhew than as a real additional ſtrength to the place; this is undoubtedly owing to the incapacity

or ſlothfulneſs of governors, who think more by what means to make moſt money of their places, than how or in what manner the town is to be defended, and to provide in time againſt the dangers which may happen in an attack.

That a town may make a conſiderable defence, though moderately fortified, is no romantick fancy, as evidently appears by the ſieges of *Vienna* and *Candia*, when they were attacked by the *Turks*; there was not a foot of ground gained by the beſiegers which the beſieged did not immediately cut off; the former made a defence of near three months till it was relieved, and would have continued ſo to the laſt inch of ground of the whole town, if it had not, and the latter held out ten years.

Conſtruction of M. Belidor*'s firſt method.*

Plate XX. This figure is part of an octagon, whoſe exterior ſide AB is 200 toiſes; the perpendicular CD, 50; the faces AE, BF, 70; and the flanks are found according to M. *Vauban*'s method.

The

The line joining the extremities *a* and b of the flanks of the ſame baſtion, ſerves as an exterior ſide to trace the front of a polygon; whoſe perpendicular c d is 13 toiſes, the faces 22; the parts d f of the lines of defence, which terminate the flanks, are 14; the dry ditch before this front is 10 toiſes at the points *a*, b, and the counterſcarp terminates at the oppoſite ſhoulders.

The rams-horns *g*, are deſcribed from a point, in the middle of the faces as centers, with a radius of 25 toiſes.

The retrenchments H, are drawn from a point h in the face at 15 toiſes from the ſhoulder to the points b, *a*, and are 25 toiſes long; the orillons k l, 8, and the flanks n m are 8 toiſes retired near the orillon, which are the chords of an arc from the oppoſite ſhoulders; the ditch before theſe retrenchments is 8 toiſes near the parapet of the baſtions, and its counterſcarp directed to the ſhoulders.

The ſaliant angle of the redout B touches the interſections of the curtains produced, and the faces terminate on the faces of the inner front within 3 toiſes of the ſhoulders; its ditch is 3 toiſes; theſe redouts are a ſtone wall of 3 or 4 feet thick, with loop holes in the faces.

The author having made no outworks to this ſyſtem, we have added ravelins and a covert-way made in the uſual manner; the great ditch is 20 toiſes before the ſaliant angles of the baſtion, and its counterſcarp is directed to the ſhoulders; and the faces of the ravelins to the outline of the Retrenchments H.

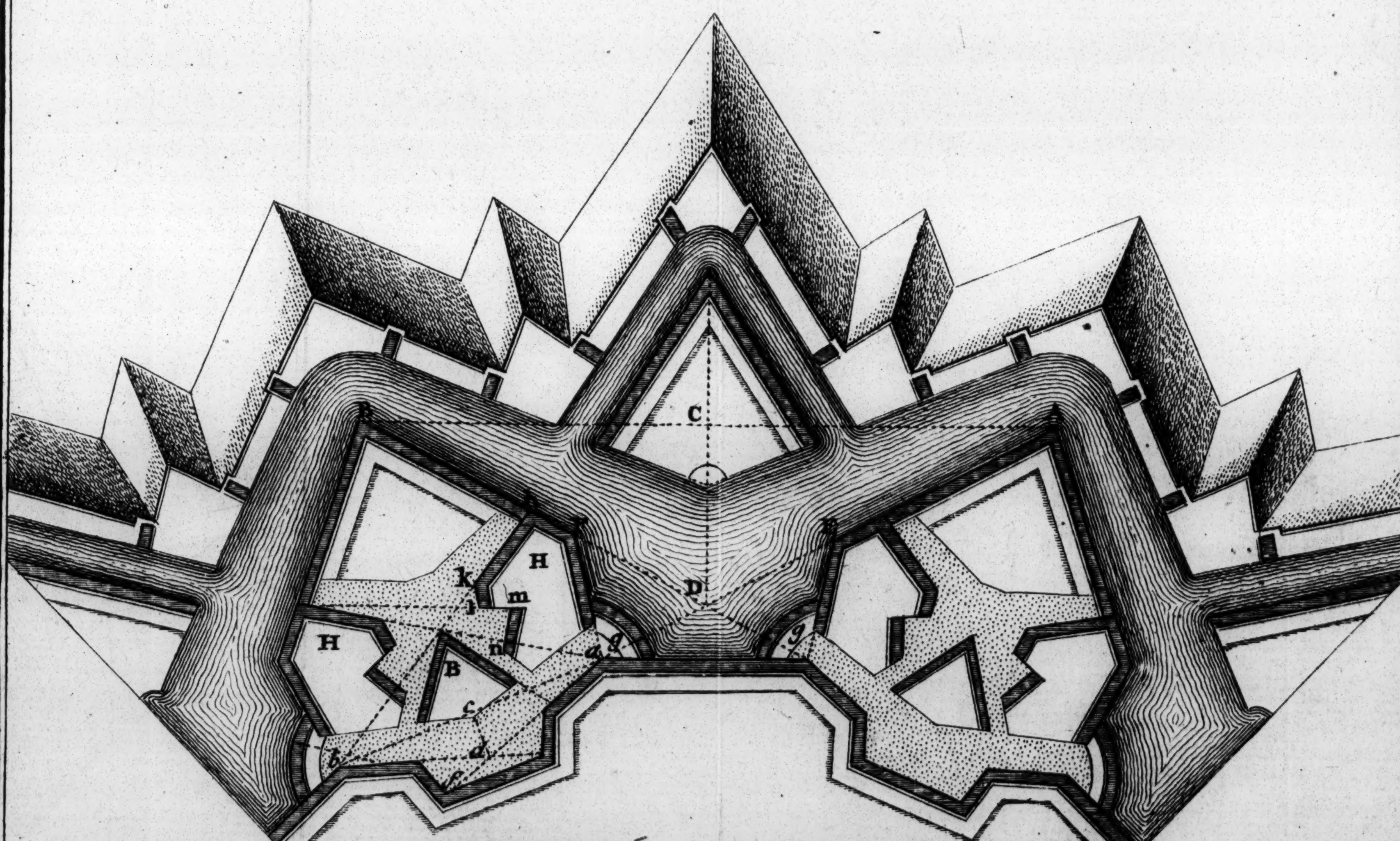
Remarks on this conſtruction.

This fortification has the advantage of all thoſe which have detached baſtions; the retrenchments within are of a good defence; but the flanks of theſe large baſtions, which are about 26 toiſes long, ſeem to be too ſmall, and the great ditch too large; for if it was only 15 or 16 toiſes at the ſaliant angles, and the counterſcarp directed to the flanks within 2 or 3 toiſes of the ſhoulders, the beſieged would not find ſo much room to place their counter batteries.

The ditch before the inner front might be ſmaller, that is, of about 5 toiſes; and then the flanks would become ſo much the longer.

As the ditches before the retrenchments H, are directly oppoſite to thoſe before the ravelins

Plate XX.



M. Belidors First Method.

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ravelin, the author deſigned to make a battery in them; for which reaſon he carries that ditch through the parapet, and leaves only the walls to cover it; but as the enemy might ſoon deſtroy the wall, and therefore need make no other breach to enter the baſtion, we have continued the parapet, and thoſe batteries might be arched and open behind.

Conſtruction of M. Belidor's *ſecond method.*

This figure is again part of an octagon, whoſe exterior ſide AB is 200 toiſes; the perpendicular CD, 55, and the faces, AE, BF, 70, as in the former; and the flanks are likewiſe found according to M. *Vauban*'s method. Pl. XXI.

The line *a b*, which paſſes through the extremities of the flanks, ſerves as an exterior ſide to the inward polygon; whoſe perpendicular cd is 5 toiſes, the faces 24, and the flanks are chords of arcs deſcribed from the oppoſite ſhoulders of the detached baſtions as centers.

This inward polygon is nothing elſe but a ſtrong wall, behind the curtain of which,

and of about 18 feet diſtance from it, is a parapet or epaulement of earth 3 toiſes thick; and within the baſtions are cavaliers, whoſe fronts are circular arcs deſcribed with a radius of about 23 or 24 toiſes; the flanks are 7 toiſes long, and gorges 32.

The counterſcarp of the ditch before this polygon is 7 toiſes at the ſaliant angles *a*, *b*, and parallel to the curtain.

The rams-horns or tenailles touch the lines of defence within 3 toiſes of the ſhoulders, and are deſcribed ſo as to meet the other lines of defence in the ſame point as the counterſcarp of the inner ditch.

The outline of the curtain between the rams-horns is 9 toiſes from the ditch.

The exterior ſide h k of the retrenchments within the detached baſtions, meets the faces within 20 toiſes from the ſhoulders; the perpendicular m n, is 17, the faces h l, 20; the chord on which the orillon is deſcribed is 5 toiſes, as likewiſe the retired part of the flank; the flanks and orillons are made according to M. *Vauban*'s method.

The circular curtain and the round part of the ditch behind it, are deſcribed with a center, 25 toiſes diſtant from the points *a b*.

The

The great ditch is 20 toiſes before the ſaliant angles of the detached baſtions, and is ſuppoſed to be dry; for which reaſon M. *Belidor* made a caponiere to go from the curtain to the ravelin, of 18 or 20 feet wide, whoſe parapets terminate on both ſides in a ſlope or glacis.

The capital of the ravelin Q is 66 toiſes, that of the redout P, 30; the faces of the ravelin are directed to thoſe of the retrenchments within the baſtions, and thoſe of the redout to the ſhoulders; the batteries in the ravelin are retired 8 toiſes behind the faces; the ditch of the ravelin is 12 toiſes, and that of the redout 7.

The ſemi-gorges of the lunettes R, are 25 toiſes, and the faces perpendicular to thoſe of the ravelin and the baſtion; the ditch before them is 8 toiſes, and the batteries S, are retired as much, and are 15 toiſes long: laſtly, the covert-way is 6 toiſes.

Remarks on this conſtruction.

If the parapet behind the curtains, and the cavaliers in the baſtions, of the body of the place had been joined to the wall, it would have been much better, ſince the wall will ſoon

be

be deſtroyed, and thereby open the place at once: the perpendicular of the great polygon is a great deal too long, it makes the baſtions too big and expenſive; the great ditch is likewiſe too wide; the earth taken out of it will be more than is required for raiſing the ramparts. As to the outworks they ſeem to be extreamly well diſpoſed, and capable of a good defence; but the whole work together is too expenſive to be ever made uſe of.

Conſtruction of M. BELIDOR*'s third method.*

Pl. XXII. This figure is likewiſe part of an octagon whoſe exterior ſide AB is 200 toiſes, the perpendicular CD, 40; the faces AE, BF, 55; the parts Dr of the lines of defence, between the perpendicular and the broken part of the curtain, 30; and the length of the broken parts rn, 25; the orillon is 9, and is part of a flank found according to M. *Vauban*'s method; the flanks are 8 toiſes retired, and are arcs of 60 degrees; the outlines of the rams-horns are 13 toiſes diſtant from each other; the paſſages at their extremities are 3, the out-

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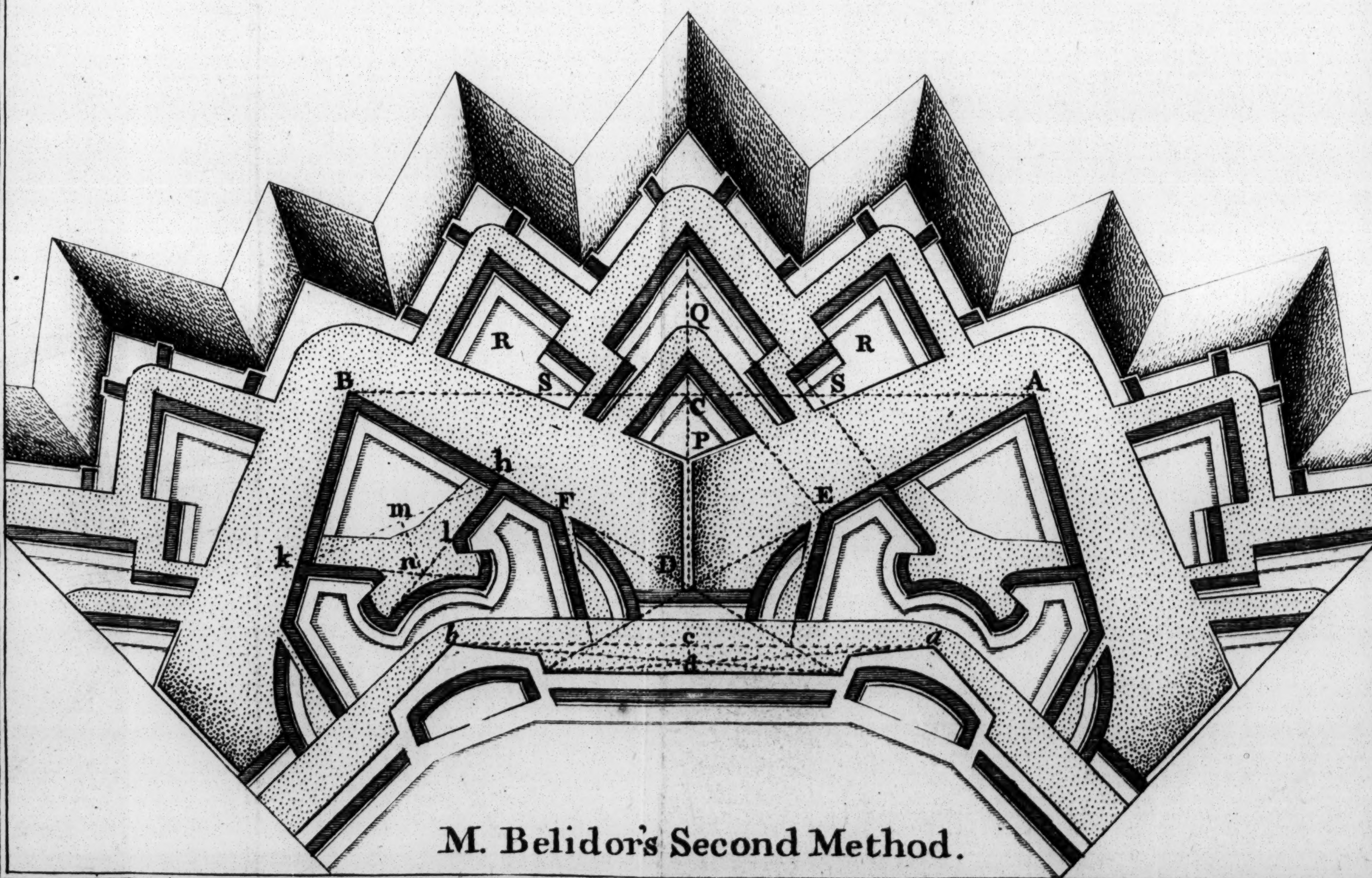
Plate XXI.



M. Belidor's Second Method.

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moſt or loweſt is deſcribed with a radius of 30 toiſes, and the other is deſcribed from the ſame center.

We have omitted the cavaliers placed in the gorges of the baſtions, as being according to our notion ſuperfluous.

The center R of the arc KL, is 18 toiſes diſtant from the re-entring angle of the counterſcarp; the chord KL is 44 toiſes, as well as the other face of the lunette; and the radius RK, 88; the battery H is 10 toiſes retired.

The figure m is a redout made of a ſtone wall full of loop holes, with a ditch of 2 toiſes before it.

The ditch before the lunettes is 12 toiſes at the ſaliant angles, and its counterſcarp directed to the extremities of the oppoſite faces.

The capital of the ravelin W is 44 toiſes, the ſemi-gorges, 31; the flanks are 9 toiſes, and directed to the ſhoulders of the baſtions.

The ditch before the ravelin is 10 toiſes, and the covert-way 6.

The glacis T, before the ſaliant angles of the baſtions, is 15 toiſes broad; the ſemi-gorges of the places of arms X are 26 toiſes; and thoſe of the redouts or ſtone wall within them, 20, reckoning from the edge of the glacis T; and the faces are drawn parallel to the oppoſite ſemi-gorges. The

The redouts S within the lunettes, are alſo made of a wall 3 or 4 feet thick full of loop-holes, with a ditch of 3 toiſes before them.

The dimenſions of the arrows and detached redouts are the ſame as thoſe in M. *Vauban*'s method, only the arrows have flanks parallel to the paſſage of 10 toiſes.

Remarks on this conſtruction.

M. *Belidor* commits the ſame faults in all his works, as almoſt all thoſe who fortify upon paper only; by conſidering how a place might be ſtrongly fortified, without troubling themſelves about the expences of building, or the great number of troops to defend it; imagining, I ſuppoſe, that a Prince, or State, ſhould ſpare no expence to ſecure the ſubjects againſt a powerful enemy. If it were only for the expence of building them, I ſhould be of their opinion; but when it is conſidered how much artillery and ammunition is required, together with the great number of troops to defend ſuch places, it may eaſily be conceived, that their firſt notions muſt neceſſarily vaniſh into ſmoak.

But

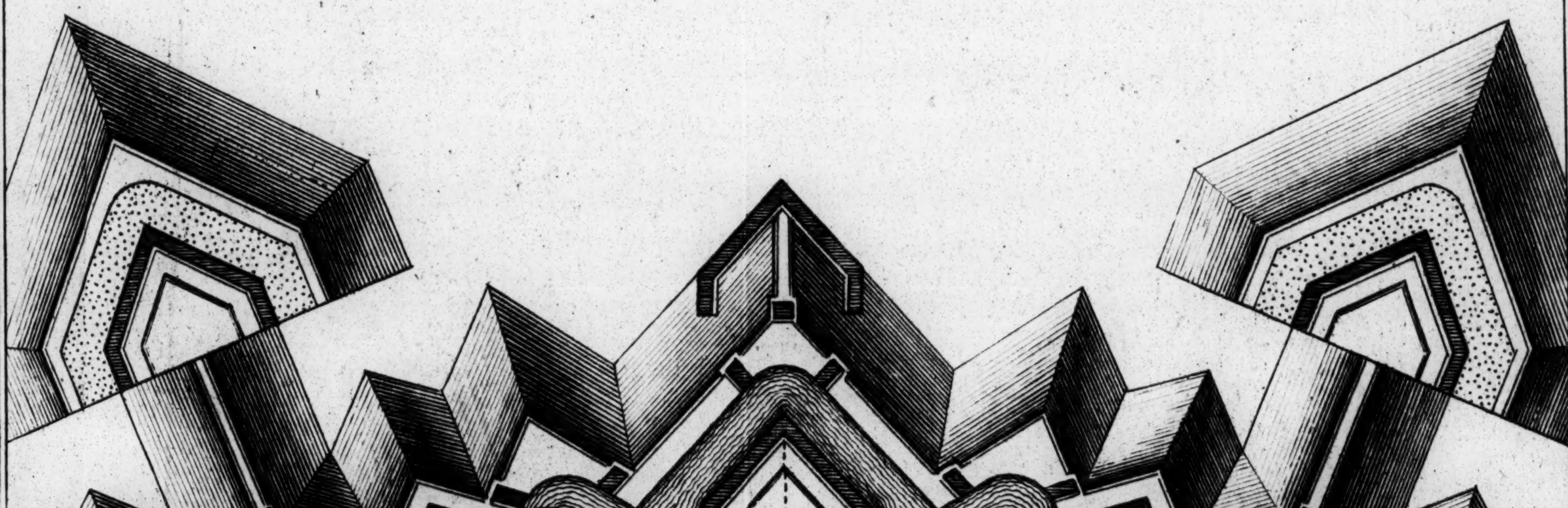
But let us enter upon particulars; the redouts m are intended to ſecure a ſafe retreat from the lunettes when they are taken; but as the beſiegers may eaſily deſtroy them with the ſame guns placed in the oppoſite ravelin, which ſerve to batter the faces of the lunettes, as likewiſe the curtain of the body of the place, they will hardly anſwer the purpoſe for which they were deſigned; he ſhould have added a parapet of 12 or 15 feet, which would have effectually ſecured the retreat. The lunettes might have been conſtructed ſo as to defend each other directly, as likewiſe to be defended directly by the oppoſite faces of the baſtions; and if there had been made counterguards inſtead of the glacis T, they would have covered the baſtions and the oppoſite flanks, and would not be liable to be taken ſword in hand, as theſe works may be taken. I ſuppoſe the author intended to ſecure them with paliſſades, but when the paliſſades are higher than the glacis, the beſiegers guns will ſoon deſtroy them, and make their defence more dangerous than uſeful; if they are equal in height with the glacis and placed near the parapet, the enemy jumps over them; and if they are farther off, they

are troublesome, and easily destroyed by the ricochet batteries; from whence it may be concluded, that these works are of little or no defence.

The places of arms are too spacious, and the counterscarps of the ditches before the detached redouts being parallel to the flanks, render the ditch before the faces defenceless, and therefore serve as retrenchments ready to receive the enemy, without requiring so much as a traverse to cover them; the flanks of the arrows are made with no more judgment than these ditches.

The rams-horns are certainly very well contrived, they are much preferable to the tenailles; they cannot be enfiladed from any one place, resist better, by their bending outwards the enemy's batteries, and render the flanks much superior to any battery that the enemy can raise against them; but the retired flanks have the same defect as those of M. *Vauban*'s, which we have shewn before; it is surprising, that no author has ever observed the badness of these kinds of flanks; the great character which M. *Vauban* has justly acquired, has probably imposed upon their understandings. The stone redouts S, and X, in the lunettes and places of arms, are undoubtedly

Plate XXII.



M. Belidors Third Method.

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doubtedly very good, they add much ſtrength to thoſe places, and ſecure a retreat to the troops which defend them.

Conſtruction of M. Blondel'*s method.*

M. *Blondel* eſtabliſhes two ſorts of fortifications, *viz.* the great whoſe exterior ſide he makes 200 toiſes, and that of the little 170; he begins with the angle made by the exterior ſides and the lines of defences, for which he obſerves the following rules. Pl.XXIII.

Subtract 90 degrees from the angle of the polygon, and take the third part of the remainder, to which add 15 degrees, and the ſum will be the angle ſought. For example, in an exagon, the angle of the polygon is 120 degrees; from which take 90 and there remains 30, the third part of which is 10; this added to 15, gives 25 for the angle required.

He makes likewiſe his lines of defence equal to $\frac{7}{10}$ of the exterior ſide; that is 119 or 120 in the little, and 140 in the great; this being premiſed, the conſtruction is as follows.

Let

Let the exterior side AB of an exagon be 170 toises; the angles ABC, BAD, 25 degrees each; the lines of defence AD, BC, 120 toises; let O be the point of intersection of these lines, bisect AO, BO in E and H; then will AE, BH be the faces, EC, HD the flanks, and CD the straight part of the curtain.

The orillons EI, LH, are 10 toises each, the flanks are retired 5 toises behind the lines EC, HD; in all polygons above an eptagon, he makes the retired flanks from 10 to 12 toises distant from these lines, in order to lengthen the curtains.

Each flank exceeds the flank before it 9 feet in height, and they are 8 toises distant from outline to outline.

The counterscarp of the ditch is drawn from the extremities I, L of the orillons, parallel to the faces of the bastions; the counterguards are but 4 toises broad, 10 or 12 feet of which are taken for the parapet; the ditch before them is 10 toises.

If from the shoulder E as center, there be an arc described through the shoulder H, and from H through E, their intersection will be in the saliant angle of the ravelin, the faces of which are directed to a point

in the faces of the baſtions within 6 toiſes of the ſhoulders; the gorge of the ravelin is determined by producing the faces of the counterguards; the ditch of the ravelin is 12 toiſes.

The ſemi-gorges of the lunettes V, are 20 toiſes; their faces parallel to the counterſcarps of the ditches, before the ravelin and counterguard, and the ditch before them is 8 toiſes; the covert-way 6, and the faces of the places of arms, which are likewiſe parallel to the counterſcarps, are as much.

The retired batteries *x*, in the baſtions and ravelins, are 7 toiſes from the faces; and their lengths are determined by the faces and counterſcarps produced of the ravelin and counterguards.

Remarks on this conſtruction.

M. *Blondel* was undoubtedly a great man in his time, and had travelled all over *Europe* and *America*, where he made very good obſervations of all the different manners of fortifying, by the ſeveral nations; as appears by his ſmall treatiſe on fortifications.

Notwithſtanding his great ſkill in diſcovering the faults committed by others, and endeavouring to avoid them, yet he fell into others of much more conſequence; neither did he conſider the great expence his method muſt coſt, (which is the caſe of moſt authors) and likewiſe the numerous artillery required to defend it.

However if the works were of good defence, he might be excuſed in neglecting the expence; but how far he has ſucceeded in that reſpect, we ſhall make appear.

He imagines, that places are generally loſt for want of having ſufficient flanks, for which reaſon he makes three, one behind another; but they are too near each other, ſo that the rubbiſh of the upper flank muſt certainly deſtroy the uſe of the lower: beſides, if any ſhells fall into the lower ones, they muſt inevitably deſtroy the troops that are there, as not having room enough to avoid them; they are likewiſe too open, and ſo more liable of being deſtroyed from the covert-way, for the counterguards are not broad enough to ſkreen thoſe flanks, as the author imagines; ſince a few mines will ſoon deſtroy them, as we have obſerved in M. *Coehorn's* method, who made his after M. *Blondel.*

The

The low batteries *x*, are likewiſe too narrow, and too much confined; though they might have been of good defence, before the ſhells were ſo much uſed, which was perhaps the caſe, when this method was invented.

Had M. *Blondel* known the uſe of ricochet batteries, he certainly would not have omitted the traverſes in the covert-way as he does; his places of arms are too ſmall to make any tolerable defence.

His great ditch is too wide by much, for it is at leaſt 25 toiſes before the faces of the baſtions; for the expence of removing the great quantity of earth out of them, to a great diſtance, is both idle and needleſs.

Conſtruction of Count Pagan's *method.*

This author eſtabliſhes three ſorts of fortifications, *viz.* the great, mean and little, whoſe principal dimenſions are contained in the following table.

TABLE.

	Great Fortification		Mean		Little	
	Square	In all the other Pol.	Square	In all the other Pol.	Square	In all the other Pol.
Exter. Sides	200	200	180	180	160	160
Perpendic.	27	30	24	30	21	30
Faces.	60	60	55	55	45	50

Let the exterior ſide AB of an octagon be 180 toiſes, the perpendicular 30, and P.XXIII. the faces 55; draw the flanks perpendicular to the lines of defence, which biſect by a line drawn from the oppoſite ſaliant angles; the one half ſerves for the orillon, the firſt flank

flank is 5 toiſes retired behind the orillon, the others are 7 toiſes diſtant from outline to outline; the faces of the cavaliers in the baſtions, are parallel to thoſe of the baſtions, and 13 toiſes diſtant from them.

The great ditch is 16 toiſes, and its counterſcarp parallel to the faces of the baſtions; the capital of the ravelin 50; and its faces are drawn to the ſhoulders; the ſemi-gorges of the redout within the ravelin 15, and the faces parallel to thoſe of the ravelin; the ditch of the ravelin 12, and that of the redout 6; the ſaliant angle of the counterguard is 40 toiſes diſtant from that of the baſtion, and 9 or 10 broad at the extremities; the ditch before the counterguard is 12, which is the ſame as that before the ravelin; the covert-way 4, and the faces of the places of arms 8, and are parallel to the oppoſite counterſcarp.

The author makes other outworks, as in his ſecond method, where the counterguards T are 25 toiſes broad; they are joined by a crooked curtain, taken in the faces produced; the diſtance AB between the inward and outward flank is 17 toiſes, and divided into three equal parts, for the three

flanks; the capital of the ravelin V, is here but 35 toises, and the faces directed to the shoulders of the counterguards; the ditch before the ravelin is 9, the rest is the same as in the first construction.

All the ramparts are 7 toises broad, out of which 3 are taken for the thickness of the parapets; in the square the lower flank is taken in the same line with the orillon, but in all the rest they are 5 toises retired behind it.

The flanks exceed each other 12 feet in height; the great ditch is 18 deep, and the body of the place is 36 high, taken from the bottom of the ditch; the ditches of the ravelins and counterguards are 12 deep; and their ramparts are 24 high from the bottom of the ditch; so that the height of the body of the place exceeds that of the outworks but by 6 feet.

The great advantage that this method had above all those which appeared then, has gained the author a great reputation, and his first system has been used in several places; and though this is the only author who has given the true position to his flanks, yet he has been found fault with on that very account, as being too much exposed, and too easily ruined by the enemy's counter-batteries

ries; most authors take it for a general maxim, that the direct defence is the best, and we have proved it in the beginning of this section; and yet a late *French* author, who takes M. *Vauban* to be his hero, says, *that if they were not so direct they would be no less good, and it is not necessary here to observe a geometrical exactness*; but how this author reconciles his manner of arguing with the above-mentioned general maxim, is a thing I do not understand; for if this maxim is not to be followed, it should not be mentioned, and if exceptions are to be made in certain cases, it is not general.

This author blames likewise Count *Pagan* for making his orillons equal to half his flanks; by which means, he says, there is so much of the flanks lost, and a lesser orillon would have been sufficient: in which he is mistaken, for there may be 4 guns placed upon the orillon; and if the Count made his retired flanks but half the straight flanks, it is because he thought that there is room enough to place as many guns in them as are necessary to defend the ditch; and by doing so, they were better hid, and not so easily dismounted by the besiegers; it is certain, that his flanks are too near one another; and if

there were but two in polygons under an octagon, it would have been much better; the ditch before the redout is but ill defended, which ſhould never be made without making tenailles likewiſe; ſo that it might be defended from thence.

His covert-way ſeems to be too narrow, and the places of arms too inconſiderable, for defending the glacis; the not making traverſes in the covert-way, is likewiſe a great miſtake, but as the ricochet batteries were not known in his time, there was not ſo much occaſion for them then, as there is now.

The counterguards in his ſecond method are too ſpacious, his propoſing to build hoſpitals, ſtore-houſes, and magazines in them, muſt prove a great detriment to their defence, unleſs thoſe buildings are demoliſhed when theſe works are attacked.

Count PAGAN'*s method corrected.*

The exterior ſide of this octagon is 200 toiſes, the perpendicular 30, the faces 60, the orillon 5; the firſt or loweſt flank is 4 toiſes retired behind the orillon, the flanks are 12 toiſes diſtant from outline to outline; the

the great ditch is drawn from the extremities of the orillons, parallel to the faces of the bastions; the ravelins are made in the manner described in plate XV.

The saliant angle of the counterguards is 35 toises distant from that of the bastions, and they are 8 toises broad at their extremities, the ditch 12; there might be retrenchments made in the counterguards, perpendicular to the middle of the faces, with a ditch before them of 3 or 4 toises.

The covert-way is 6 toises, the semi-gorges of the places of arms 20, and the faces are perpendicular to the counterscarps.

Remarks on this construction.

All the works in this fortification have a very good defence; the compactness of the works, and the little expence in respect to the extent of the town, makes this method far preferable to any other.

We have made but two traverses in each branch of the covert-way, but because of their length, there may be made three, to prevent better the enfilades of the ricochet batteries; these traverses need not be so thick as they are generally made, for 10 or 12 feet would

would be sufficient to resist the ricochet batteries.

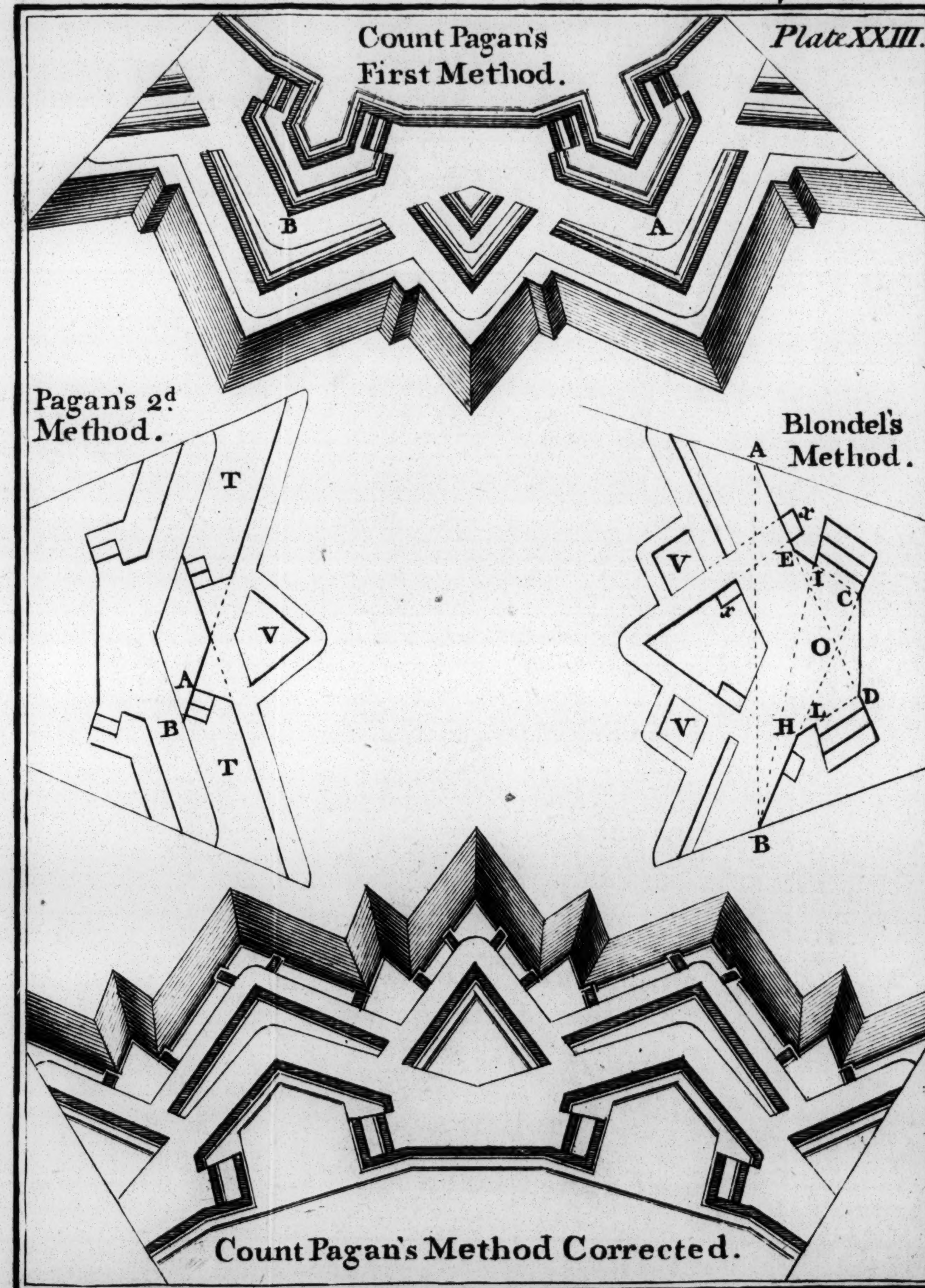
As the flanks are here perpendicular to the lines of defence, it was necessary to make the counterscarp of the great ditch parallel to these lines, according to what has been said with respect to the true position of the flanks, at the beginning of this section.

If the lower flanks were arched and open behind, in all places that have two or three it would be much better, since this would effectually prevent the enfilading them, when they are not covered by orillons; they would likewise be out of danger from the shells, especially when there is a ditch behind, and the level ground goes sloping towards the ditch.

SECTION III.

Of irregular Fortification.

THE most essential principle in fortification, consists in making all the fronts of a place equally strong, so that the enemy may find no advantage in attacking either of the sides,



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ſides; this can happen no otherwiſe in a regular fortification ſituated in a plain or even ground; but as there are but few places which are not irregular, either in their works or ſituations, and the nature of the ground may be ſuch as makes it impracticable to build them regular, without too great expence; it is ſo much the more neceſſary to ſhew in what conſiſts the ſtrength or weakneſs of a town irregularly fortified, ſo that the weakeſt part may be made ſtronger by additional outworks; as likewiſe if ſuch a place is to be attacked, to know which is the ſtrongeſt or weakeſt part.

All the authors who have wrote on fortification, that I have ſeen, are ſo deficient in regard to this, that not the leaſt knowledge can be gathered from their writings, they do not even mention any thing about it; from whence it might be concluded, that there can be given no general rule, whereby the ſtrength or weakneſs can be diſcovered; and if we conſider the ſeveral attacks that were made in the late wars, one would be inclined to think, that the engineers were no ways acquainted with it.

That M. *Vauban* underſtood irregular fortification perfectly well, is plain from thoſe places

places he has fortified of that kind; and yet his commentators mention nothing of it; they very often laviſhly beſtow their praiſes on ſome of his works, which do not deſerve it, and are ſilent upon thoſe which are very juſtly to be eſteemed.

When the ſituation of a place is ſuch that it cannot be regularly fortified, it ſhould be contrived to make it nearly ſo; that is, inſtead of inſcribing it in a circle, it ſhould be inſcribed in an oval, ſo that one half may be like and equal to the other half; and when this cannot be done, it ſhould be made as regular as it poſſibly can be, and as much as the nature of the ground will admit of.

But to reduce irregular fortification into ſome form, that from thence their perfections and imperfections may be diſcovered; we ſhall ſuppoſe in the firſt place, that one half of the place is equal and like the other half; and then ſhall ſhew the application of this principle, in all ſorts of irregular places.

Proposition.

Pl.XXIV. If a fortification be inſcribed in an oval, that is, if the one half is equal and like

like the other half; I ſay, that the ſides CD, GH on the flat parts are ſtronger than the ſides AB, EF, on the narrow parts, ſuppoſing all the exterior ſides equal and the place equally fortified.

It muſt be conſidered, that a front may be eſteemed more or leſs ſtrong, in proportion as the beſiegers are obliged to make more or leſs works in their approaches; and when theſe approaches are ſuch, as being produced, ſhall always fall without the fortification, otherwiſe they may be ſeen in front by ſome of its parts; therefore when the angles BCD, CDE of the polygon are very great, and the beſieger comes within a ſmall diſtance of the works, he cannot approach any nearer without being ſeen in front, excepting by a direct ſap, with traverſes; and as this way of approaching preſents but a ſmall front, the beſieged, who have a much larger, may oppoſe what obſtacle they pleaſe.

And on the contrary, if the angles HAB, ABC of the polygon are very ſmall, the beſiegers may carry their approaches to the very counterſcarp, and have always a larger front than the beſieged.

Moreover,

Moreover, as the beſiegers muſt extend their approaches to three fronts, whether they are ſmall or large, the work of the approaches before the front BCDE, will be to the work before the front HABC, as the line BE is to the line HC nearly; that is, as the greater axis of the oval is to the leſſer; conſequently the front CD on the flat ſide, is ſtronger than the front AB on the narrow ſide.

COROLLARY I.

Hence it follows, that the longer the exterior ſide CD of a polygon is, provided the lines of defence are within the reach of muſket-ſhot, and the angles BCD, CDE of the polygon the ſame, the ſtronger the front will be; ſince the works become more ſpacious, may hold more troops to defend them, and the beſiegers are obliged to extend their trenches farther.

COROLLARY II.

It follows likewiſe, that the greater the angles of the polygon BCD, CDE are, the exterior ſides being the ſame, the ſtronger

the

the front CD will be; becauſe the length of the line BE increaſes, and the extent of the beſiegers approaches in proportion, as has been proved in the foregoing propoſition; conſequently the ſtrength of a fortification increaſes in proportion to the number and length of its ſides; that is, a dodecagon is ſtronger than an octagon, ſuppoſing the length of their ſides equal; and an octagon, whoſe ſides are 200 toiſes each, is ſtronger than another octagon, whoſe ſides are only 180; and hence a right line fortified, is the ſtrongeſt of all, contrary to the opinion of moſt engineers; there are even ſome, who imagine preciſely the contrary to be true.

N. B. The truth of the foregoing propoſition and its corollaries, is likewiſe confirmed by practice and experience; firſt, as to practice, if the plan of *Namur* be conſidered, it will be found, that at St. *Nicolas* gate, where the town is narroweſt, there are more works than in any other part; at *Cambray* near the *Cantipers* and *Seille* gates, where the place is narrower than any where elſe, there are horn-works; at *Lille*, near the gate of the ſick, is a caſtle in the curtain, a ravelin and counterguard before it, as like-

wiſe a horn-work before each baſtion; abundance of other examples might be given, which confirm the foregoing propoſition.

Experience has ſhewn likewiſe that large places moderately fortified, have made better defences in proportion, than ſmall ones of more works; for *Metz* in *Lorrain* was beſieged, without ſucceſs, by *Charles* the Vth emperor of *Germany* and king of *Spain*, although he had an army of 100,000 men, and the town was only fortified with a ſingle rampart, without baſtions and a dry ditch before it; *Lille* in *Flanders*, when beſieged by the allies, made a much better defence than any other place in that country; and laſtly, *Prague* in *Bohemia*, when beſieged by the *Auſtrians*, which has but a rampart with baſtions and a dry ditch, and yet the beſiegers were obliged to abandon it, without being in a condition to take it.

It may be ſaid, that theſe places had ſtrong gariſons, ſkilful governors, and well provided with every thing neceſſary for a good defence, and that the *Auſtrians* before *Prague* were in want of artillery and ammunition to carry on the ſiege, and that the ſame place was taken a year before by the King of *Pruſſia* and the *French*, in the firſt aſſault.

To

To this may be answered, that these places were only garisoned in proportion to their extent, and *Lille* was obliged to surrender sooner than it would have done for want of powder and ammunition; and as to *Prague*, if the *Austrians* had been well provided with necessaries, they would have found it a difficult matter to force it, as may be judged by their beginning, since what works and batteries they made, were destroyed by the besieged, and their cannon nailed up.

There are several other advantages in large fortified places, which cannot possibly be had in small ones; as that the sick and wounded may be lodged in a quarter remote from the attack, where they are pretty secure from the besiegers shells and cannon-shot; the several artificers necessary in a siege may do their business with less disturbance, and those troops which are not on duty, may rest and refresh themselves, whereby they are better able to do their duty; and lastly, the powder may be lodged in several magazines at some distance from each other, so that it is not in the besiegers power to destroy them, at least not all; whereas it is a difficult matter to lodge powder in secure places in small fortifications, the sick and wounded

are in a continual apprehension of being destroyed by the shells of the enemy, as happened in the siege of *Ostend* last year, where there was not any one place secure from danger; and the troops not on duty, having no place to rest themselves in without fear, will never be able to act with that spirit as they would do otherwise.

It appears to me a vain imagination to think, that a fortification ever so strong, with a small garison, can resist long a numerous army; for if their loss is ever so inconsiderable, in respect to that of the besiegers, it must nevertheless prove a great detriment to them in the end; on the contrary, nothing, in my opinion, but a proportionable number of troops in a garison, to that of the besiegers army, can make a proper defence according to the bigness of the place.

Having thus proved the foregoing proposition, and confirmed it by practice and experience, it will serve as a maxim or a general rule, on which irregular fortification is to be established; as likewise a standard, whereby the strength or weakness of those already fortified, may be discovered.

As the ſituations of irregular places are ſo various, it is impoſſible either to enumerate them, or to give an example of each; therefore we ſhall endeavour to give ſuch as are moſt common, and uſeful at the ſame time, by which the intelligent reader may be guided in any other caſe that may occur to him.

If a ſituation is ſuch, as to make it impoſſible to reduce it into a regular form, it ſhould be brought to one as near as can be done; that is, if the polygon cannot be inſcribed in a circle, it ſhould be inſcribed in an ellipſis or oval; but as this inſcription is pretty difficult, we will give another method, which anſwers the ſame purpoſe, and is very eaſy in practice.

Suppoſe a ſpot of ground to be reducible to the figure ACEG, draw BF, AF parallel to each other, ſo as the interval may be 180 or 200 toiſes, more or leſs, according as the nature of the ground will admit. P. XXIV.

To theſe lines draw CH, DG perpendicular, and equally diſtant from the points B, E, ſo as their interval be equal to that of the lines BE, AF; this done, draw DC, GH parallel to AF, BE, and equally diſtant from them, and from their inter-

ſections C, D, H, G, with D G, C H, as centers, deſcribe arcs, with a radius equal to C D, or G H, ſo as to interſect the lines A F, B E, in A, B, E, F, and join the points A,B, and E,F; then will ABCDEFGH, be an oblong octagon, ſo that one half will be ſimilar and equal to the other half.

Much after the ſame manner may be deſcribed any other polygon; for example, in an exagon, inſtead of drawing the two lines C H, D G, there need be but one, in a decagon three, and in a dodecagon four.

If it ſhould ſo happen, as that all the ſides cannot be made equal without too much expence; then the ſides A B, E F, on the narroweſt part of the polygon, ſhould be the longeſt if poſſible, on account of its being the weakeſt, as has been proved before.

It may ſometimes happen, that the figure cannot be made regular in any reſpect; in ſuch a caſe, the ſtrength of each ſide muſt be eſtimated according to the works a beſieger is obliged to make in the attack, and according to the obſtacles he meets with in his approaches.

If ſome parts of a place are commanded in front by a hill, the parapet muſt be raiſed

8 or

8 or 9 feet high, inſtead of 6 only, as is cuſtomary; if it is in the reverſe, then a traverſe muſt be made along the capital of a ſufficient height, to cover the work, or in both caſes, cavaliers may be made nearly in the ſame form of the baſtion.

It may ſometimes happen, that there is an abſolute neceſſity of fortifying a re-entring angle, in which caſe, the works muſt be conſtructed in ſuch a manner, that there may be no part but what can be flanked, or ſeen by ſome other part; in ſhort, all that art and knowledge can furniſh ſhould be uſed in irregular works; the weakeſt parts ſhould be made ſtrong by an addition of works; care muſt be taken that no part be commanded by a neighbouring hill, or riſing ground; and if that cannot be avoided, to raiſe traverſes or cavaliers; in general, particular care ſhould be taken to make every ſide equally ſtrong, and to be as frugal in the expence as poſſible, that the expence of building and the maintaining a garriſon, may not exceed the advantage ariſing from the fortifying of the place.

I have ſeen a project of a fortification which was to be built near a paſs, to occupy a hill which commands a neighbouring for-

tification, of a very odd figure, although made by an engineer of great repute; it was impossible to judge, from the disposition of the works, for what intent the fortification was to be made.

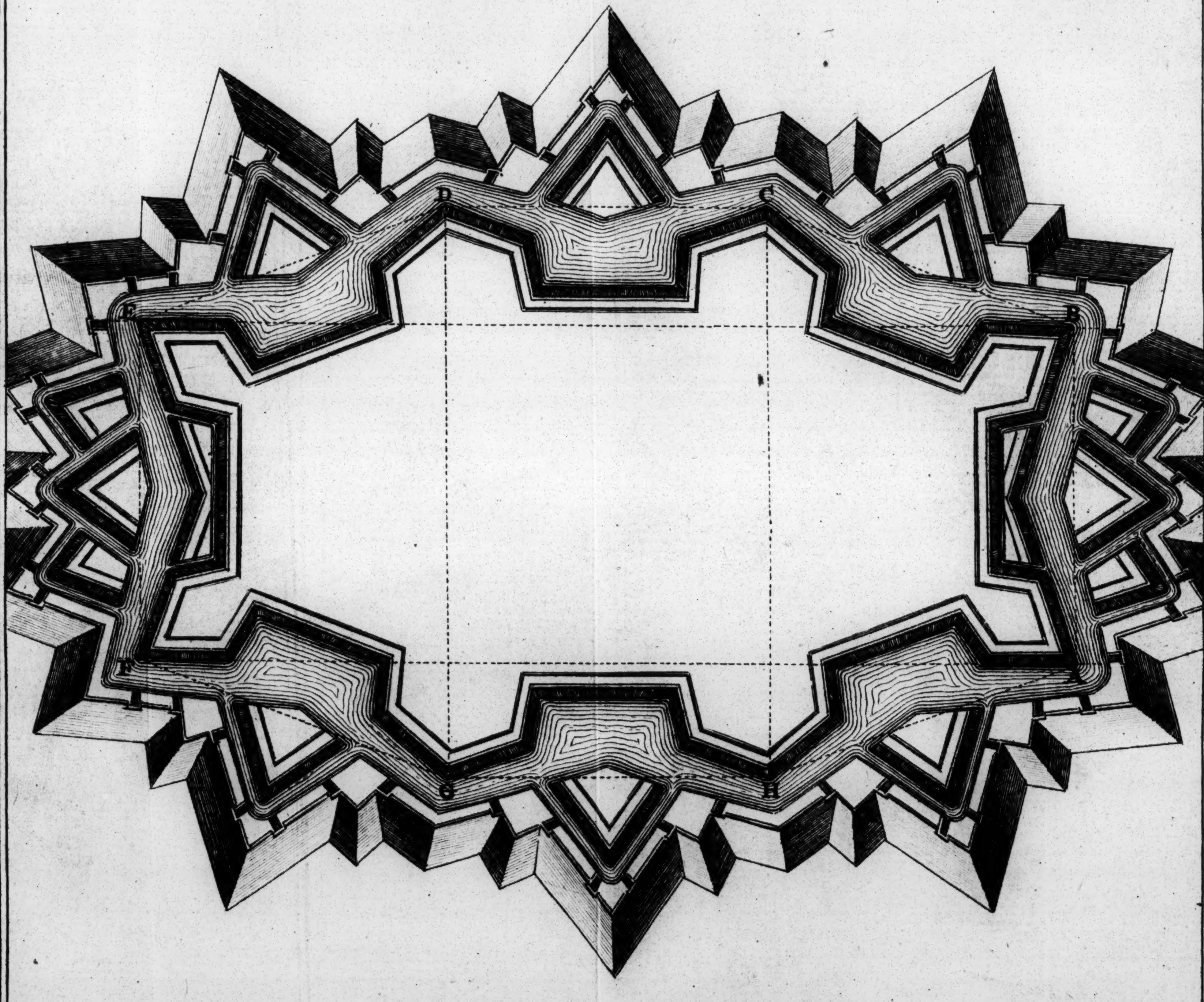
When a place is to be fortified, it is of the greatest importance to employ skilful engineers to form the project; and to have it afterwards examined with great care and judgment by others, in order to be satisfied that the figure is properly adapted to the situation and nature of the ground, and the number of works answerable to the importance of the place; but above all things, the expence of building, as likewise the number of troops for the garison, should be well considered; for without that it is morally impossible that the place should answer the end for which it is built.

Construction of an irregular place situated in an open country.

If the place to be fortified be an old town inclosed by a wall or rampart, as it most frequently happens, the engineer is to consider well, all the different circumstances of the figure, situation, and nature of the ground,

p. 150.

Plate XXIV.



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ground, to regulate his plan accordingly, ſo as to avoid the diſadvantages, and gain all the advantages poſſible; he ſhould examine, whether by cutting off ſome parts of the old wall or rampart, and taking in ſome ground, the place cannot be reduced into a regular figure, or nearly ſo; for, if that can be done without increaſing the expence conſiderably, it ſhould by no means be omitted; old towns have often towers placed from diſtance to diſtance, as *Douay*, *Tournay*, and many other places, which are generally made uſe of, and mended when it may be done; if there is a rampart without baſtions or towers, it muſt be well conſidered, whether baſtions may not be added, or if it is not better to make only ſome outworks; if the ditch about this rampart is not too wide and deep, it would be advantageous to make detached baſtions, otherwiſe ravelins and counterguards muſt be conſtructed; ſpecial care muſt be taken, to make all the ſides of the polygon as nearly equal as poſſible, and that the length of the lines of defence do not exceed the reach of muſket-ſhot; but if that cannot be done, thoſe ſides which are on the narroweſt part ſhould be made the longeſt.

If it ſhould happen, that ſome of the ſides are inacceſſible or of very difficult approach, either on account of ſome precipice, marſhy ground or inundation, they may be made much longer than the others, which are of eaſy acceſs, and the flanks need not be ſo large as the reſt; by doing ſo, there will be ſome expences ſaved, which may be uſed in making the other ſides ſtronger by adding more outworks.

There are few ſituations, but what are more advantageous in ſome parts than in others; it is therefore the buſineſs of an engineer to diſtinguiſh them, and to render thoſe ſides ſtrong by art, which are not ſo by nature.

If the ſituation is low and watry, lunettes or tenaillons, and ſuch other ſmall outworks ſhould be conſtructed, becauſe they are not of any great expence, and may make a very good defence; but if one ſide of the place is only low, and running water is to be had, a ſecond ditch and covert-way, with lunettes, may be made, by obſerving, that if the firſt glacis is made to ſlope, ſo as to become even with the level of the water in the ſecond ditch; or if the water can be ſwelled, by means of dykes or ſluices,

ſo

ſo as to overflow the beſt part of the firſt glacis, it ſhould be done; for by ſo doing, theſe works will be able to make a very good defence, ſince the beſiegers will find it a difficult matter to lodge themſelves upon this glacis, which cannot be done but within a few toiſes of the firſt covert-way, where the beſieged are ready to receive them, and to deſtroy their works with great advantage; whereas the enemy cannot ſupport their workmen but from the ſecond covert-way, which is too far off to be of any great ſervice to them.

But if the ſituation is of a dry nature, without any water about it, caponiers ſhould be made in the great ditch, from the curtains to the ravelin, and batteries raiſed in the entrance of the ditch before the ravelin, whoſe parapet muſt ſlope off into a glacis, ſo as to afford no cover for the enemy behind them; arrows and detached redouts are likewiſe very proper to be uſed in ſuch a caſe, and ſometimes horn or crown-works, if it ſhould be thought convenient; but theſe works ſhould never be conſtructed, without an abſolute neceſſity, either to occupy a ſpot of ground which might be advantageous to the enemy, or to cover ſome

gate or entrance into the town, for they are of great expence, and their defence seems not to be anſwerable to it.

Moſt of the places in *Flanders* are fortified with horn-works, ſuch as *Ipres*, *Tournay*, *Lille*, and others; *Lille* has four, *Ipres* as many, two of which are injudiciouſly placed near one another. I am ſurpriſed that M. *Vauban*, who undoubtedly was in all reſpects the beſt engineer, and who fortified many places with ſo much judgment, ſhould have been ſo fond of making theſe kind of works, which are, in my opinion, the worſt of all his fortifications, in the manner they have been conſtructed in the above-mentioned places; it muſt certainly have been before he had acquired that knowledge, for which he is ſo much eſteemed; and what renders this conjecture probable is, that he has but ſeldom made uſe of them, in the conſtruction of thoſe places which he fortified in his latter time; and where he made any, it was always to cover a gate or entrance into the town.

If the place to be fortified is new, and the ſituation will not admit of a regular conſtruction; particular care muſt be taken, in chuſing ſuch a ſpot of ground as is

is most advantageous, and least liable to any disadvantages, either in the building or in the maintaining of it; all hills or rising grounds should be avoided, which might command any part of the works, marshy grounds, because such situations are unwholesome, or lakes and standing waters for the same reason, excepting a lake is, or may be made navigable; good water should be had either within the place or near it, for it is absolutely necessary for men and cattle; the air should be wholesome, otherwise the continual sickness that may reign in such a place, might prevent people to come and live in it, and the garison would not be in a condition to defend themselves as they ought to do; in short, all the different circumstances attending such an undertaking should be maturely considered, before a resolution is taken to fortify any place.

When a situation is pitched upon, the next thing to be considered, is the bigness of the town and the number of its outworks, which must absolutely depend upon the consequence such a place is of to a nation; if it is only to guard a pass, or entrance into a country, it need not be so large; but if it is to be a place either to promote or to protect trade, it should be large and commo-

dious; the ſtreets ſhould be wide, and the buildings regular and convenient; as to what regards the fortification, its conſtruction ſhould depend on the nature of the ſituation, and the number of works, on the funds, or expence a prince or a nation will be at; which however ought to be according to the benefit ariſing from ſuch a place. For as ſuch undertakings are of very great expence, an engineer cannot be too ſparing in his works, on the contrary the greateſt oeconomy ſhould be uſed, both in regard to the number of works, and to their conſtruction. The body of the place may have * revetements quite up to the top, or only in part, and the reſt turfed; but as to the outworks, they ſhould have half revetements, or they may be made with turf only; as being not ſo neceſſary to prevent the place from being ſurpriſed, and may nevertheleſs make a good defence.

The plate XXIV, is the plan of an octagon, one half of which is ſimilar and equal to the other half; it being ſuppoſed, that the ſituation would not admit of a fortification quite regular; the exterior ſides are each

* Revetements are chiefly made to prevent a place from being ſurpriſed; outworks do not want to be made ſo, the taking them by ſurpriſe is of no great conſequence, except in a ſiege, when other cautions are uſed to prevent it.

each 180 toiſes, and the works are conſtructed according to our method; but becauſe the ſides AB, EF, are weaker than the reſt, as has been proved before; we have added tenailles, redouts in the ravelins, and lunettes, to render them nearly equal in ſtrength with the others. Inſtead of lunettes, any other works may be made, as it may be thought convenient and according to the nature of the ground. If it ſhould be judged neceſſary to add other outworks to the ravelins all round the place, care muſt be taken to add likewiſe more to the fronts AB, EF, in order to render the advantages and diſadvantages of attacking on either ſide equal.

Conſtruction of an irregular place, ſituated on a hill, or rock.

In the conſtruction of ſuch places, care muſt be taken that no neighbouring hill commands any part of the works, the town ſhould always be built on the higheſt part; but if it ſhould be thought more convenient to place it lower, then the upper part muſt be fortified with a fort; the ſituation ſhould be made level as near as poſſible, by removing the earth from ſome places to fill up

up others; and if it cannot well be levelled without extraordinary expence, works must be made on the highest part, so as to command and protect the lower; the works ought to occupy all the upper part of the hill, but if it should be too extensive to be all inclosed, or so irregular as not to be fortified without great inconveniency, the parts which fall without should be fortified with some detached works, and a communication with the place must be made either above or under ground. There should be no cavity or hollow roads, within canon-shot, round about the place, where the enemy might be able to approach under cover; if there should happen to be a spring, near the top of the hill, it should be inclosed in the fortification, or if that cannot be done, by some work or other; for there is nothing more necessary, and at the same time scarcer in such situations than water, for which reason there cannot be too much care taken in providing it; several cisterns are to be made to receive the rain water, and to preserve it; wells should be dug likewise, though ever so deep, the water of which will serve for common use.

Places built on hills or rocks, should never be large, for their use is generally to

guard paſſes or inlets into a country, and are ſeldom uſeful in traffick, and it is a difficult matter to provide for a large gariſon in ſuch ſituations, neither ſhould any ſuch place be built without ſome very material reaſons; but when it is abſolutely neceſſary, great care and precautions ſhould be taken to render the works as perfect as the ſituation will admit of, and at the ſame time to be as frugal in the expence as poſſible.

Conſtruction of irregular Fortifications, ſituated near rivers, lakes, or the ſea.

As the intent of building theſe kind of places, is chiefly to facilitate and protect trade, it is of much more importance than any other kind, eſpecially in maritime countries, where the principal ſtrength and power depends on it; for which reaſon, we ſhall treat of it more largely than of any other part.

The firſt thing to be conſidered is their ſituations, which ought to be ſuch as to afford a good harbour for ſhipping, of a ſafe and eaſy entrance in ſtormy weather; but as it is hardly poſſible to find any, where ſhips may go in and lie ſecure, with all winds,

winds, care ſhould be taken to make them ſafe to enter with thoſe winds which are moſt dangerous; but it is not ſufficient that the harbour is ſafe againſt ſtormy weather, they ſhould likewiſe be ſo againſt an enemy, both by land and water; for it often happens that ſhips are deſtroyed where it was imagined they were ſecure, which is of too great a conſequence not to be provided againſt; for which reaſon, forts or batteries muſt be built in the moſt convenient places, to prevent the enemy's ſhips from coming too near, ſo as to be able to canonade thoſe in the harbour, or fling ſhells amongſt them; and if there is any danger of an enemy's approach by land, high ramparts and edifices muſt be built, ſo as to cover them.

When a river is pretty large, and it is not convenient for making a harbour without great expence, the ſhips may ride along the ſhore, which, for that reaſon, muſt be made acceſſible for ſhips of burthen; this may be done by advancing the quay into the river, if the water is too ſhallow, or by digging the river ſufficiently deep for that purpoſe.

And to prevent any enemy from coming up the river, forts muſt be built on both ſides, eſpecially when there is any turnings or

or windings. *Antwerp* is ſuch a place, for the *Scheld* is ſufficiently deep to carry ſhips of great burthen, which may come quite near the town-wall; and ſeveral forts are built below it on both ſides, ſo that it would not be an eaſy matter for an enemy to come up the river.

When the river is but ſmall, ſo that no ſhips of burthen can come through it; it is ſufficient to make it run through ſome of the works, where proper landing places are contrived, from whence the goods may be carried into the place; as at *Sarrelouis*, where a horn-work is built beyond the *Sarre*, in the gorge of which the goods are landed.

If the breadth of the river does not exceed 200 yards, it commonly paſſes through the middle of the town, and proper quays are made on each ſide; in ſuch a caſe, the fortification is ſo contrived as that the river paſſes through the curtain, in order to have a baſtion on each ſide to defend the coming in and going out.

When M. *Vauban* fortified near rivers, he made always the exterior ſide near the water much longer than any of the others; such is *Hunningen* on the *Rhine* and *Sarre-*

louis on the *Sarre*; but for what reaſon he fortified theſe places in that manner, has not been told by any author I know of; for thoſe who beſtow moſt praiſes on him are quite ſilent in this reſpect, although theſe works ſhew better, in my opinion, his great ſkill in fortification, than many others for which he is generally eſteemed; it is true, authors treat in general ſo ſuperficially of irregular fortification, as would incline one to believe, that they either knew not the importance of the ſubject, or elſe imagined it was impoſſible to reduce it under general rules or maxims, whereby its perfections and imperfections might be diſcovered.

But it is plain, from what has been demonſtrated before, that the ſides which terminate at the river, are the weakeſt; becauſe the beſiegers trenches being ſecured by the river, they may draw moſt of their troops off, and act therefore with more vigour and ſtrength on the other ſide: beſides, as the ſtrength of a ſide increaſes in proportion, as the angle of the polygon is greater, by making the ſide next the river longer, the angles at its extremities become wider, and conſequently the adjacent ſides ſtronger.

Then

There are other advantages, beſides theſe mentioned already, which ariſe from the lengthening that ſide; for if the river is pretty deep, ſo as not to be fordable, that ſide is not liable to be attacked; and by increaſing its length, the capacity of the place increaſes much more in proportion to the expence, than if more ſides were made; the center of the place will be likewiſe nearer the river, which makes it more convenient for tranſporting the goods from the water-ſide to any part of the town.

To illuſtrate this method of M. *Vauban*'s, we ſhall give the plan of *Hunningen*; this place was built for the ſake of having a bridge over the *Rhine*, for which reaſon he made it only a pentagon; the ſide AB next to the river is 200 toiſes, and each of the others but 180; the body of the place, as likewiſe all the outworks, are conſtructed according to his firſt method, by obſerving that the perpendicular to the ſide AB is only 25 toiſes, according to the table given at the beginning of his firſt method, and the capital of the ravelin before that front 28; whereas thoſe of the others are 50. Pl. XXV.

About the ſpace *abc*, which lies before the front AB, is a ſtone-wall, and the paſ-

ſages x, x, are ſhut up with ſluices, to retain the water in the ditches in dry ſeaſons, and to prevent an enemy from deſtroying the ſluice near the point c, whereby the water would run out and leave the ditches dry; the redout y was built in the little iſland hard by, in order to cover that ſluice; without this precaution the place might be inſulted from the river ſide, where the water is ſhallow in dry ſeaſons.

The hornwork K beyond the *Rhine* was built to cover the bridge, but as this work cannot be well defended croſs the river, the hornwork H was made to ſupport the other. There are likewiſe horn-works before the baſtions E, F, and a little work before the baſtion G, called *Paté*, which we have omitted for want of room.

There ſeems to be nothing in this fortification but what is well contrived, and here certainly the author has ſhewn his ſkill; the only things which appear to me ſuperfluous, are the horn-works placed before the baſtions E, F, and the *paté* before the baſtion G; for I think there are too many works conſidering the ſmallneſs of the place; and as the horn-works were chiefly made to ſecure a ſafe retreat, over the wet ditch be-

yon

yond the glacis, as I ſuppoſe, in caſe of a ſally; a couple of detached redouts might as well have anſwered the purpoſe.

Some of my readers will undoudtedly be ſurpriſed to read my encomium on this for-tification, whilſt M. *Coehorn* looks upon it as n ill contrived piece of work; but if they will be pleaſed to conſider that he was miſled y a falſe or incorrect plan, for that very hing he ſaid was wanting, meaning the work *abc*, which retains the water in the itches, was actually executed by M. *Vauban*, this plan ſhews.

Before we finiſh the deſcription of this lan, we ſhall ſhew how to find the long de AB, as being uſeful in the following ork.

After having inſcribed the two ſides GE, F, in a circle, draw the diameter CD, as to be equally diſtant from the line ning the points E, F, that is parallel to it; this diameter ſet off 100 toiſes on each e of the center, from theſe points draw o indefinite perpendiculars to the diameter; n if from the points E, F, as centers, two s are deſcribed with a radius of 180 toiſes, ir interſections A and B, with the ſaid rpendiculars, will determine the long ſide

A B, as likewiſe the other two F B and E A. In like manner may be found the long o ſhort ſide of any polygon whatſoever.

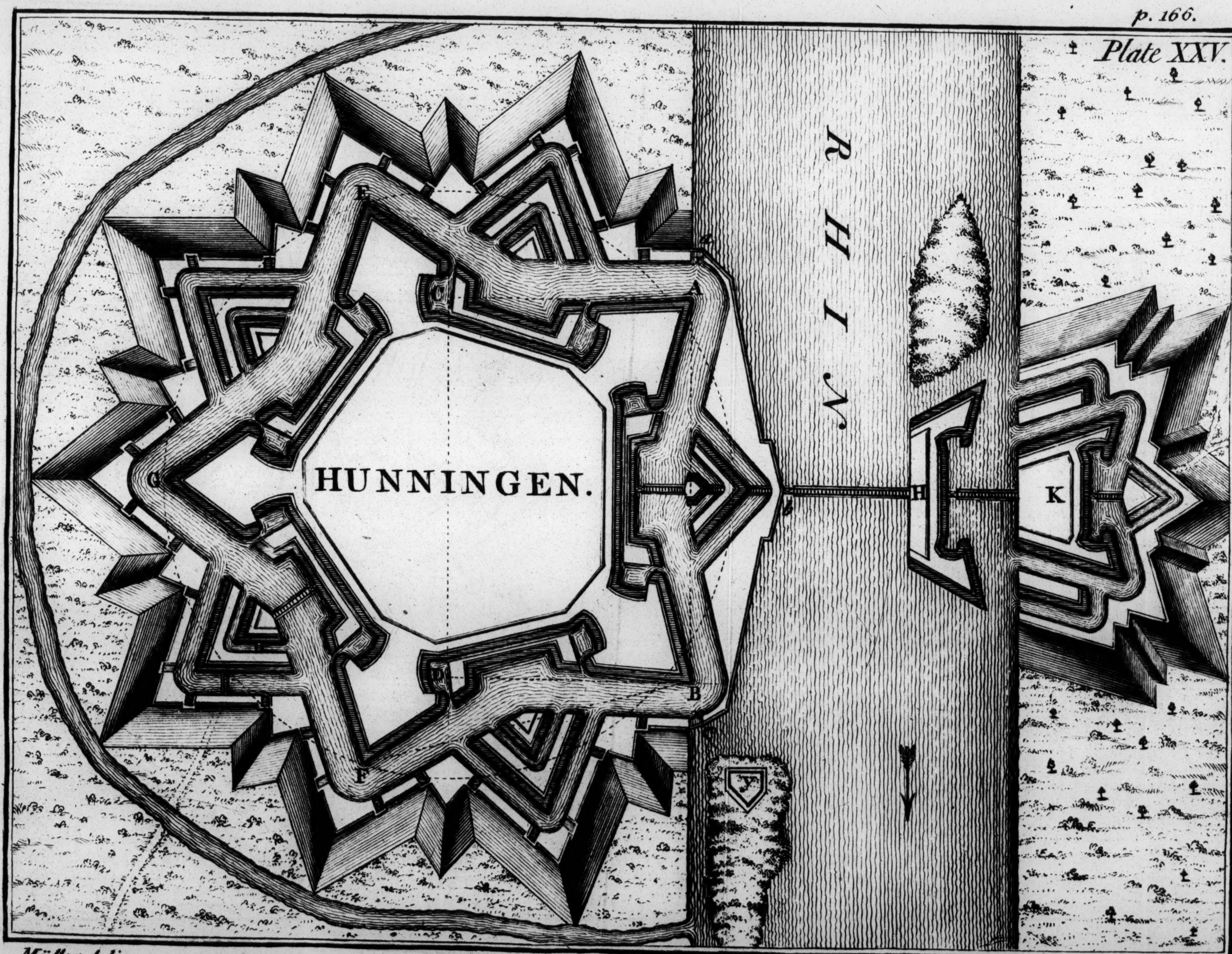
When a place near a river is to be for tified, for the ſafety of commerce, partic lar care ſhould be taken in leaving a goo ſpace between the houſes and the water ſid to have a landing place for goods brought b water; it ſhould alſo be contrived to hav proper places for ſhips and boats to lie ſecu in ſtormy weather, and in time of a ſieg and as water carriage is very advantage for tranſporting goods from one place to an ther, as likewiſe for bringing the neceſſa materials, not only for building the forti cation, but alſo the place itſelf, the expen will be leſſened conſiderably, when this co venience can be had; for which reaſon, pla ſhould never be built any where elſe near rivers, lakes, or near the ſea; exce ing in extraordinary caſes, where it canno avoided.

For the better underſtanding this im tant part of fortification, we ſhall give ſ examples of various kinds, from which reader may gather the manner of fortif others of the ſame nature.

EXAM

p. 166.

Plate XXV.



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Example I.

We ſhall ſuppoſe a river of 100 toiſes Pl. XXVI. or more broad, and ſuch as is always navigable, at leaſt for ſmall veſſels or boats, and the ſituation to be ſuch as to admit of a regular fortification; the body of the place is a regular octagon, and the flat ſide next to the river, cuts off a fourth part from the circle, and is lengthened ſo as to be 360 toiſes; the perpendiculars are 25 toiſes only on this ſide, and all the others 30; the faces 50, and the flanks are found according to our method; the great ditch is 16 toiſes, and the ravelins are conſtructed as uſual; the lunettes L near the river, have one of their faces perpendicular to the middle of thoſe of the adjacent ravelins, and the others are parallel to the flat ſide; their ditch is 12 toiſes. Within the flat baſtion is a baſon B, to receive ſhips 40 toiſes broad, and its length is terminated by perpendicular lines drawn from the extremities of the adjacent curtains, and a paſſage is made in each flank of 10 toiſes, for the ſhips going in and out; theſe paſſages are ſhut up with ſluices, with a kind of a paſſage over them, in order to have a

free communication with the flat baſtion, and from thence over the bridge into the fort G, on the other ſide of the river.

This fort is conſtructed in the following manner; from the ſaliant angle of the flat baſtion as center, deſcribe an arc with a radius of 200 toiſes; on which ſet off two chords of 120 toiſes each, for the exterior ſides, the perpendiculars to which are 20 and the faces 35; the branches of this fort are perpendicular to the oppoſite faces of the baſtions; the ditch before this work is 12, that of the ravelin 8; and the ravelin as well as the flanks are conſtructed according to our method. The ſemi-gorges of the lunettes k are 20 toiſes each; and the faces are, the one perpendicular and the other parallel to the branches of the fort; they ſerve to cover the entrance into the baſon B, which might otherwiſe be ſeen from thence; the ditch before theſe lunettes is 8 toiſes.

The gorge of the redout H, is 40 toiſes, the flanks 10; the faces 30, and the ditch before it 6; this work ſerves for ſecuring the retreat when the fort G is taken; and whilſt the enemy is endeavouring to get maſters of it, the troops may retire in the dark over the bridge into the town.

The

The market place A is about 70 toiſes one way, and 50 the other; all the ſtreets 6, which is rather too much for the by ones; our deſign is not ſo much to give the particular dimenſions of them, as to ſhew that they ſhould be perpendicular to the river, and croſs each other at right angles; reſerving the reſt for the practical part of fortification.

The buildings C, C, are deſigned for naval ſtore-houſes; E a ſtore-houſe for land ſervice, D for barracks, and F are the bridges near the gates of the town.

We have given the conſtruction of the body of the place and ravelins only, without determining the reſt of the outworks, whoſe number and capacities depend on the importance of the place. It ought to be remembered, that it muſt be better fortified near the river than any where elſe, it being the weakeſt part, as has been proved before.

If the ſituation does not admit of a regular fortification, then it muſt be conſtructed in ſuch a manner, as to approach as near to it as can well be done, without being at an exceſſive expence; and if there ſhould be a hill, or riſing ground within cannon-ſhot, which can ſee into ſome of the works, it muſt either be fortified, or cavaliers

cavaliers are to be made in the oppoſite baſtions.

It may ſometimes happen, that the river forms a natural baſon for ſhipping, or they may be made ſerviceable by a little work; ſuch an advantage is by no means to be neglected, a ſkilful engineer will know how to uſe all the advantages, which the nature of the ground affords; ſo as to be ſaving in the expences, and to make the place in the moſt convenient manner.

The landing places may be made in the great ditch, near the curtains next to the river, if it is thought proper; in ſuch a caſe, part of thoſe curtains may be left open in order to have a quay, and round theſe kind of harbours, ſome works ſhould be conſtructed to ſecure the ſhips in time of war.

Example II.

P.XXVII. It may ſometimes be judged more con venient to build the place on both ſides th river, than on one only; in ſuch a caſ the river ſhould always paſs through the cu tains in order to have a flank on each ſid to defend its entrance and coming out;

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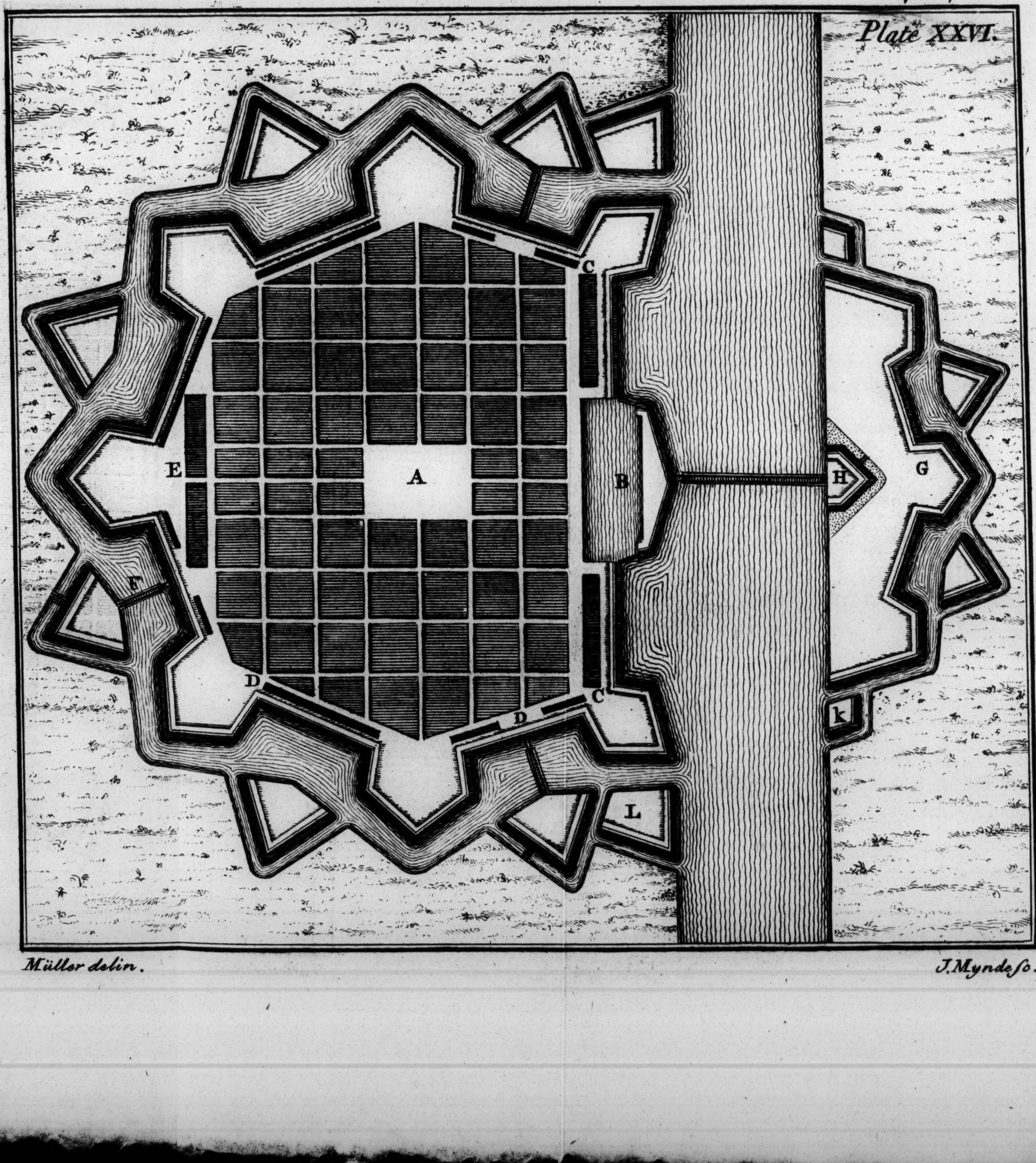

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the river is not very large, the curtains may be built acroſs the river upon arches, which may be made to ſhut in the night, or in time of a ſiege, with portcullices; and the middle arch may be made wider than the reſt, and left open at top, with a draw bridge over it, for ſhips to ſail through. But if the river is above a 100 toiſes large, the building curtains acroſs would be too expenſive; in ſuch a caſe a fort, ſuch as B, may be made in the middle of it; from whence chains and booms may be laid to the ſhore in the night, and in time of danger.

The conſtruction of the body of the place may be as follows.

Suppoſing the ſituation to be ſuch as to admit of a regular conſtruction; each ſide is a part of a regular octagon, inſcribed in a circle, whoſe centers O are within 10 toiſes from the river; the body of the place is conſtructed according to our method, and the ditch is 16 toiſes; as to the reſt of the works, their number and bigneſs may be made in what manner it is thought proper, and according to the importance of the place.

The ſtreets are to be perpendicular to the river, and to croſs each other at right angles;

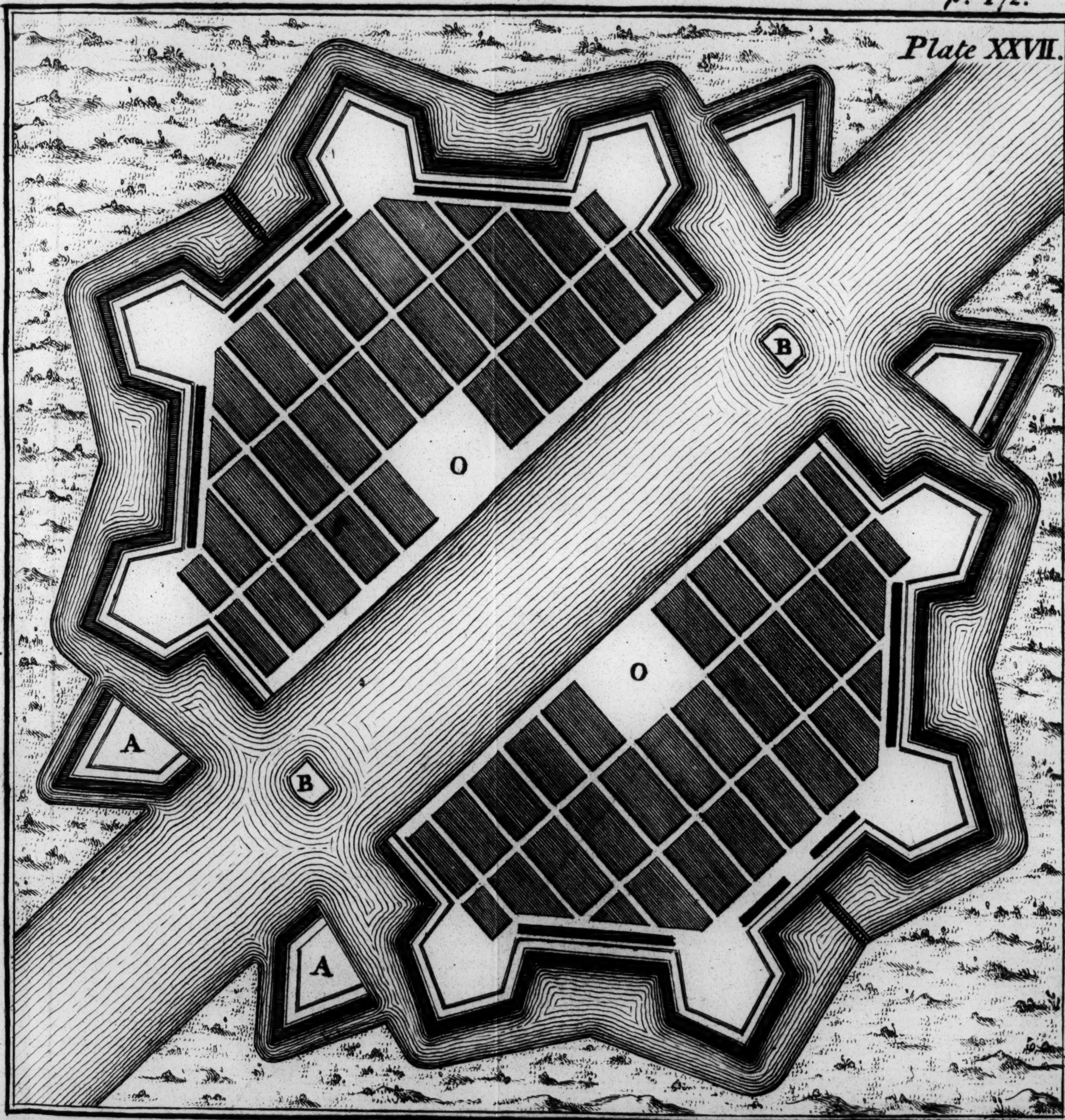
angles; and for a greater conveniency of transſporting goods from the ſhips to the market, a market place may be made on each ſide near the river. We have added lunettes, ſuch as A, to defend the entrance and going out of the river, one of the faces of which is perpendicular to the oppoſite faces of the baſtions within 25 toiſes of the ſhoulders; this face is about 60 toiſes long, and the others are ſo drawn as to be perpendicular to each other.

As the enemy will hardly attack the place near the river, becauſe an attack made on one ſide only, is liable to be enfiladed from the other by the gariſon; and when it is made on both ſides, the troops are divided, and not in a condition to ſupport each other; it is not therefore neceſſary to make the fortification ſtronger there; on the contrary, as it will probably be attacked on the ſide quite oppoſite to the river, ſome more works ſhould be made in this place.

Notwithſtanding the booms and chains, which are to be laid acroſs the river, in the night and in time of danger, the enemy may find an opportunity to force his way through, whereby the place might eaſily be taken. To prevent which a wall of 8 or

p. 172.

Plate XXVII.



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or 10 feet high ſhould be built along the river, with iron gates oppoſite to the ſtreets, ſo as to be locked up at night.

EXAMPLE III.

Places built near the ſea are of the greateſt importance to a nation on account of trade; ſo they require likewiſe the greateſt care in the chuſing their ſituations, in ſuch a manner as to be of the leaſt expence in building, and the moſt convenient for ſhipping. We ſhall ſhew how ſuch a place may be fortified, when the ſituation is plain and even, and where there is no harbour formed by nature.

This plan is a part of a regular decagon, four ſides of which are cut off for the flat ſide next to the ſea, the perpendiculars to which are but 15 toiſes; all the reſt of the works are conſtructed as uſual; as the place is weakeſt near the ſhore, we have added lunettes with bonnets, to make it nearly equal in ſtrength there, with the reſt of the ſides; we have added no outworks beſides ravelins, becauſe their number and capacities depend on the importance of the place. Plate XXVIII.

The

The baſons or harbours A, A, are 30 toiſes broad and 80 long, and the entrance into them 10; this we imagine might be ſufficient for ſhips going in and out: however, it may be made more or leſs according as it will be thought convenient: our deſign being rather to ſhew the figure, and in what manner it may be done in ſome caſes, than to pretend to give the exact dimenſions, which ought to be determined by experience, or according to the nature of the ſituation.

The channel or road C leading into the baſons A, A, is 18 toiſes broad, and muſt be as long as the ſhallow water goes; B, B, are two ſemi-circular forts to defend the entrance into the harbour, which being made of that figure, are better for defence on every ſide. If theſe forts ſhould not be thought ſufficient, one or two more may be made, between theſe and the place, or on ſome flats or ſands where the ſhips cannot come too near.

The buildings D, D, are naval ſtore-houſes, E a ſtore-houſe for land ſervice, and F the barracks.

The ſtreets and other buildings are to be made nearly in the manner expreſſed here in

in the plan; but the market-place might be made quite open to the ſea, if it is thought proper.

We ſuppoſed here in this plan, that there is no harbour formed by nature, for which reaſon an artificial one is made; but if there be any bay, creek, or large baſon formed by the ſea, or a river, it ought to be uſed and inlarged, if neceſſary, and ſometimes moles are made to form a harbour, as at *Gibraltar*; by which a great deal of labour and expences are ſaved.

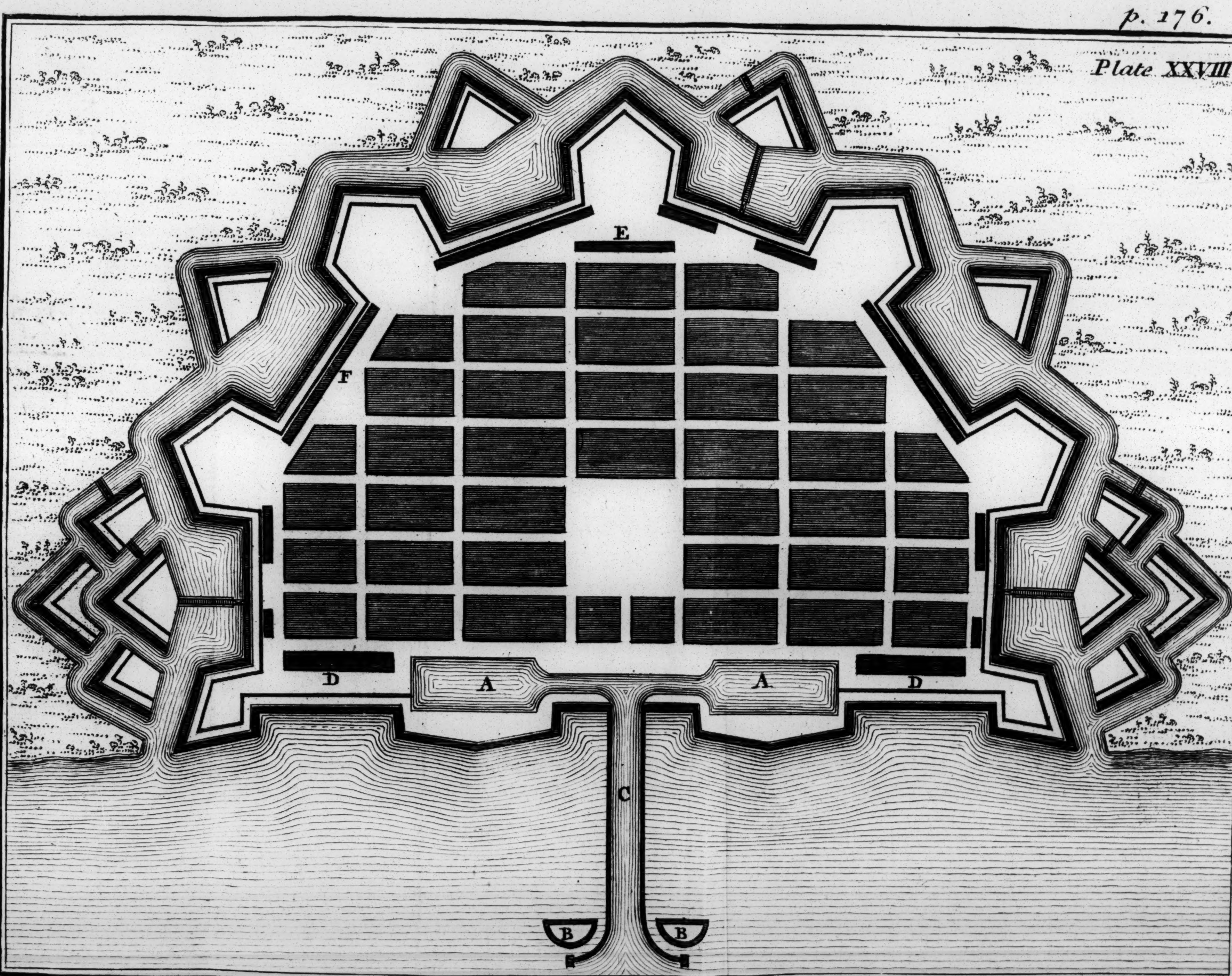
If a place is to be fortified in an iſland formed by the ſea, and there is a navigable river; then the propereſt ſituation will be at its entrance, if the river is but ſmall; or a little way up in the land, if it is pretty large, ſo as not to be in danger of a bombardment from the ſea; but it muſt be obſerved, that here and in all places of this kind, the conveniency for making a good harbour muſt chiefly be conſulted, whoſe entrance ſhould always be defended by two or more forts or batteries, placed on both ſides of it.

It will alſo be proper to take particular notice, that if an enemy may land any where thereabouts, the forts muſt be built ſo

ſo as to be every where equally ſtrong, in order to be in a condition to reſiſt which way ſoever they may make their attack; the want of this conſideration has often proved of dangerous conſequence, becauſe if theſe forts or batteries may be ſurpriſed, the harbour will lie open to the enemy, who therefore may enter without any further danger, deſtroy the ſhips, and take the town. It is by no means ſufficient to raiſe batteries in ſuch places as command the entrance of a harbour, without conſidering likewiſe whether their conſtruction is ſuch, as to anſwer the purpoſe for which they are built, they will otherwiſe be of very little uſe in the defence of the place: if there ſhould be but one or two ſuch places where an enemy may land, they ought to be fortified with ſome ſmall works; but if there are ſeveral, it is much better to build two good forts, one on each ſide of the harbour near ſome ſhallow water, ſo that the ſhips may not approach too near, to prevent their being demoliſhed by them.

If a ſmall iſland formed by a river is to be fortified, care muſt be taken to occupy the whole iſland, if poſſible, in order that the works of the fortification may defend

Plate XXVIII.



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every part of the firm land whereby the enemy will not be able to land any where without great danger and difficulty; but if the iſland ſhould be ſo large that the whole cannot be conveniently fortified, and ſome parts are acceſſible and others not, the place ſhould then be built in the moſt acceſſible part, and the others, if not too many, may be fortified with ſmall forts or batteries.

If there is any lake of ſome length, or which diſcharges its waters into a navigable river, a place built near it will be very convenient for trade; although a lake has no communication with the ſea, or is not navigable, at leaſt for large ſhips, yet it may be very uſeful for trading with the country round about; the bigneſs and ſtrength of ſuch a place muſt be according to its importance.

We have thus explained, in a few words, the manner of fortifying places ſituated near navigable rivers, lakes, or the ſea, which is far from being ſufficient to give a compleat notion of the ſubject; it would require a whole volume to enumerate all the different circumſtances that may poſſibly happen, either in reſpect to the various ſituations formed by nature, the conveniences required to ſave expences, or their importance with regard

to traffick; for all theſe conſiderations are to be maturely conſidered and well weighed at leiſure, before an undertaking of this importance is put in execution.

It would be a help to the reader, if a great many plans of places already executed were collected; for by examining them with all the attention and care that is poſſible, and not omitting the leaſt circumſtances, ariſing from their different ſituations or nature of the ground; as likewiſe from the importance they are of either to protect or increaſe trade; and then taking notice for what reaſons works are made in ſuch a manner in one caſe, and different in another, a right notion might be formed of the ſubject, ſo as to be able to proceed in any other caſe of the like nature. But as this would ſwell the work too much, and draw it into a greater length, than is agreeable to our purpoſe, we ſhall finiſh this part, with explaining the ſituations of a few places already built, to ſupply, in ſome meaſure, what is wanting to compleat the ſubject.

At *Dunkirk* is a bank of ſand before the entrance into the harbour nearly parallel to the ſhore, which is an admirable defence againſt any bombardment; for when

ſhips

ſhips lie without it, they are too far from the place to do it any damage; and if they ſhould venture to go between this bank and the ſhore, there is a fort built ſo nigh, which would deſtroy them, as having not ſufficient room for working a ſhip, ſo as to turn about; the channel leading into the harbour is pretty long, and defended by two forts on one ſide, and three on the other, which makes it impracticable for an enemy to paſs through it. Another great convenience this port has, is, that there are three rivers, coming from the inland country, which run into the harbour; at their entrances are ſluices, which are ſhut up at high water and opened at low, which carry out the mud and ſand brought in by the ſea, and thereby prevent the harbour from being choaked up.

Whenever a ſituation is to be found, that has theſe advantages, it ſhould not be neglected, ſince it ſaves great expences in keeping the harbour always clear, and renders an attack by ſea impracticable.

Oſtend lies cloſe to the ſea, and the road leading into the harbour, which lies oppoſite to the ſea, paſſes by one ſide of it; but as the entrance is very difficult, and no wind

but a north-weſt one will permit any ſhips to enter, and the town being liable to a bombardment, ſuch a ſituation as this is not to be uſed, excepting other reaſons occur for fortifying it; this place has one advantage, that it cannot be attacked by land but on one ſide only, which is along the ſhore, becauſe all the other ſides may be ſurrounded with water in the time of a ſiege, and therefore the acceſſible ſide may be made ſo ſtrong, as to make it a difficult matter to take it that way.

Antwerp lies near the *Scheld*, and has no other harbour than the river itſelf, which is large and navigable for ſhips of great burthen. A citadel is built above the town, to defend it againſt an enemy coming by land, and below are ſeveral forts on both ſides the river, to prevent an enemy from approaching it by water; this place is ſo happily ſituated, that it was formerly the principal trading place of all *Flanders* and adjacent countries; but afterwards, when the *Dutch* had ſhaked off the yoke of the *Spaniards*, and the beſt part of *Flanders* was ſubjected to the houſe of *Auſtria*; the *Dutch* prohibited all the trade of this place, and transferred it to their own dominions.

By

By what has been ſaid with reſpect to this place, the reader may eaſily perceive the great advantages it has; and that few ſituations deſerve ſo much notice to be taken of them as this.

Boulogne is ſituated near a creek going pretty far up the land, at the entrance of which is a bar difficult to paſs without a good guide; and on one ſide is a high hill which commands it entirely, ſo that the place is ſecure againſt any attack by ſea; for which reaſon, ſuch a ſituation is not to be neglected.

Dieppe is another place ſituated near the ſea; the channel or entrance into the harbour is guarded by two peers or moles, which harbour is nearly perpendicular to the ſea, with a turning near the channel.

The channel and harbour of this place ſeem to be very convenient, and as they are chiefly formed by nature, the expence of making them muſt be inconſiderable; but the place itſelf is ſituated ſo near the ſea as to make it liable to a bombardment, ſuch a ſituation ſhould therefore be avoided, excepting forts can be made ſo as to prevent the approach of an enemy's fleet.

The laſt ſea-port we ſhall mention, is the famous one of *Toulon*, ſituated in the

Mediteranean; the entrance into the bay or road is large and ſpacious, covered by a neck of land, and defended by three caſtles, two forts, and ſix batteries; the road is ſo large that a whole fleet may ride in it; adjoining to the town are incloſed two large harbours by peers or moles, the one for the king's ſhips, and the other for merchant men; the firſt is much larger than the ſecond, and its entrance is made in the form of an V open at bottom, by which the ſhips are carried in gradually, without danger of running againſt the peers.

Pl. XXIX. To give an idea of this harbour, which is certainly one of the fineſt in *Europe*, we have repreſented the plan of the town and harbour only in the 29th plate, though it would have been much better for the reader's information, to have added the road and entrance likewiſe; but this could not be brought into ſo ſmall a compaſs as to be inſerted in this book, without rendring the parts indiſtinct. From this the reader may form a judgment, how to proceed, if he ſhould find himſelf employed in ſuch ſort of works: for nothing can be more in-

N. B. This plan has by miſtake being reverſed by the engraver; ſo that the king's harbour which appears on the right, ſhould be on the left.

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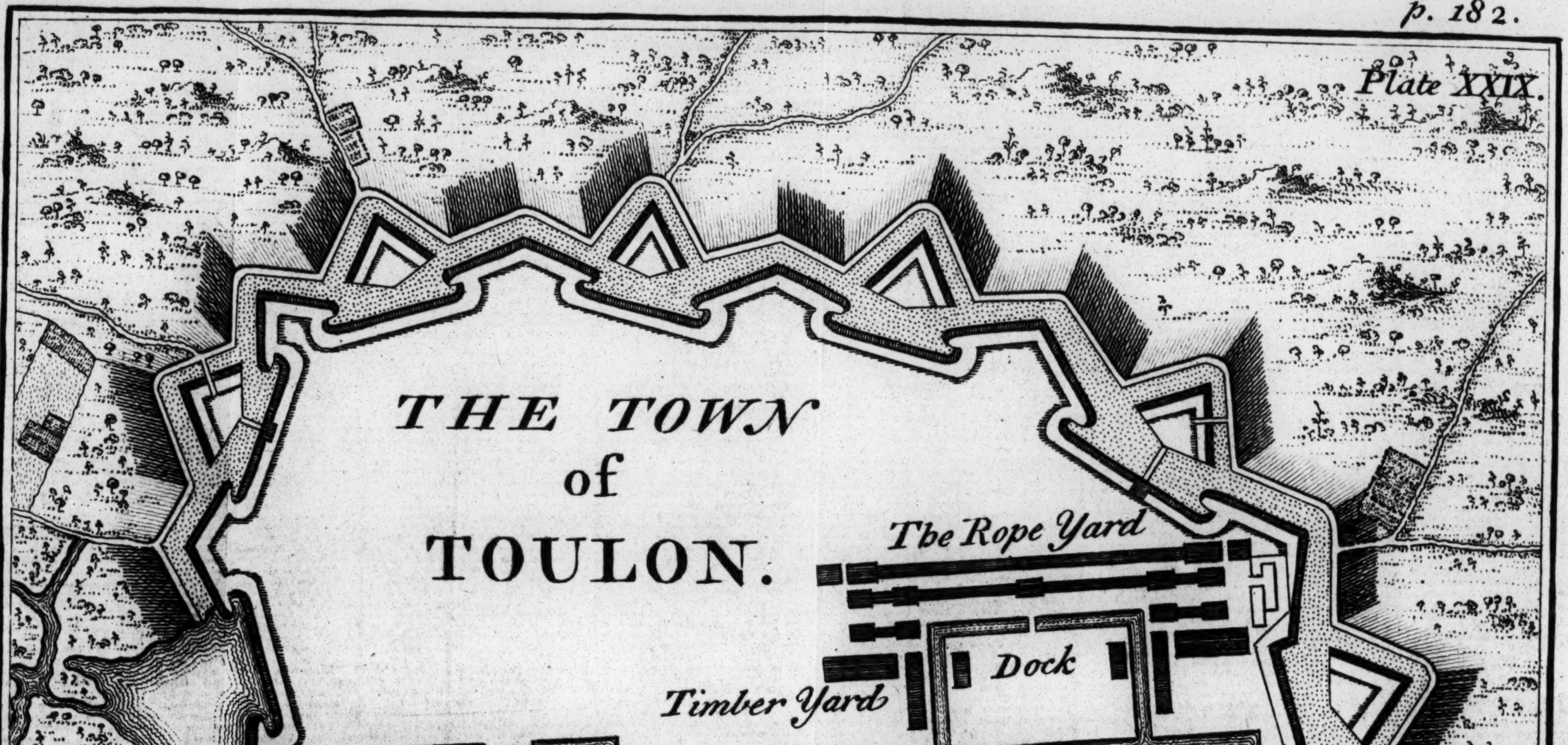

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ſtructive than examples of works executed, the precepts only without them, will never make ſo ſtrong an impreſſion upon the mind, as is required in the execution of any project, which muſt be perfectly well underſtood beforehand.

Before we finiſh this ſubject, we think it will not be improper to give the principal conditions required in a ſea-port town, and which ought to be obſerved in the building ſuch places.

Firſt, the harbour is of the greateſt importance in all places of trade by ſea; it ought therefore to be well conſidered, whether there is one to be found, which is formed by nature, ſuch as a bay, creek, or a baſon, or if by the help of a little labour one may be made; for to make one entirely by art, becomes generally too expenſive, and they can never be made ſo large, as to contain a conſiderable number of ſhips; whether the road before the harbour has a ſufficient depth of water for ſhips of great burthen to ride in it ſafely; whether there is good anchoring, and the ſhips may be ſafe in ſtormy weather, and eſpecially the ſhips may enter by ſuch winds as are moſt dangerous upon that coaſt; if the entrance can be defended againſt

a ſtrong fleet, by means of forts, caſtles, or batteries built on each ſide of it; and laſtly, whether the ſhips riding in the road and harbour, are ſafe againſt a bombardment.

Secondly, whether the chief or principal materials for building the fortification and the town, are to be had near the place, or thereabouts; ſuch as ſtone, timber, lime, &c. or if not, whether they can be brought by water, otherwiſe the conſtruction of ſuch a place would be attended with an immenſe expence; whether the country round about is plentiful in thoſe things which are neceſſary for the ſuſtenance of men and cattle; for ſhould it be barren, the bringing theſe neceſſaries from diſtant countries, might be attended with great difficulties, eſpecially in time of war, when an enemy might intercept them, and thereby reduce the place by famine; whether the air is good and the ſituation wholeſome in all reſpects, and good water to be found near or thereabouts; for if it ſhould be unwholeſome, people would not care to ſettle there, and thoſe that would venture, would neither increaſe or act with that ſpirit and chearfulneſs required for the improvement of new ſettlements; and as to good water it is ſo neceſſary, that it is im-

poſſible

poſſible to do without it; laſtly, it ſhould be conſidered, whether the country round about it produces ſuch commodities as are fit for trade; how it may be improved, and where it may be tranſported to, either for ſale or exchange, for ſome others which may turn to account either at home or abroad.

All theſe things being well conſidered, together with the nature of the ground, the plan of the place muſt be made accordingly; in which the conſtruction of the works ought neither to be exceſſive in the expence for building of them, nor yet ſo ſmall as not ſufficiently to defend the place, but ſuch as the importance of the place requires, and the ſituation admits of. As there are few ſituations which have all the advantages which could be deſired, care muſt be taken to pitch upon ſuch as have moſt of them, and where the reſt may be ſupplied partly by art.

The moſt favourable ſituations for building maritime towns, are near the mouth or entrance of a navigable river, eſpecially when it is free from rocks and ſands, and is of eaſy acceſs for ſhipping. In ſuch ſituations the harbour may be made on the op-

poſite

poſite ſide of the place, in reſpect to the ſea, as at *Oſtend*, and ſome other places.

If the river is large, the place may be built at ſome diſtance from the ſea, as *Antwerp*; and there is no occaſion for a particular harbour, the river itſelf being ſufficient; the only thing to be obſerved is, that there may be ſome place, where ſhips may be ſafe in ſtormy weather; a hill or riſing ground near the river, which ſhelters it from the moſt dangerous winds, will be very advantageous for that purpoſe.

Theſe ſituations near large navigable rivers, not too far from the ſea, are the moſt advantageous that can be found; for they have all the advantages of a ſea-port town, and are not liable to be attacked by an enemy's fleet, and are abſolutely free from bombardment, excepting by land, ſince a few forts built in the turnings of a river will be ſufficient to prevent any attempt that way; beſides the merchandiſe brought by water, may be carried into the country to foreign markets with little trouble and no great expence.

As the greateſt wealth of a country depends on traffick by ſea, ſo there is nothing of ſo great conſequence, as the well pro-

protecting it, by building proper harbours to contain ſhips in ſafety, and to make them ſo that they may be defended againſt the force or ſtratagem of an enemy: proper landing places ſhould not be omitted, nor good magazines and convenient ſtore-houſes to lodge the goods in, and in general, every thing ſhould be thought of that any ways may contribute to eaſy conveyances, and the proper diſpoſing of them. But as nature is ſo various in its operations that it is impoſſible to foreſee all the different circumſtances which may happen, ſo it is likewiſe impoſſible to deſcribe them, and conſequently the choice of a proper ſituation, and the manner of conſtructing ſuch a place, according to its importance, muſt be referred to the ſagacity of the engineer employed in the undertaking, who certainly can have no larger field to diſplay his knowledge, than on ſuch occaſions.

Of CITADELS.

In a country newly conquered, or one of a long ſtanding, where the inhabitants are ſuſpected of being diſaffected to the government, citadels are built to keep them in awe,

and prevent all attempts they may make to ſhake off their dependency; as likewiſe to ſecure the gariſon from their treachery, which they might be willing to undertake againſt them.

It happens likewiſe ſometimes, that when a town is large and wealthy, and has little or no fortification, a citadel is built to ſecure it againſt an enemy, when it would be too expenſive to fortify the town itſelf; and to ſerve for a place of ſecurity, to carry in the beſt effects of the inhabitants in time of danger, when the approach of an enemy is apprehended.

There are many ſuch places in *Italy*, which are large and wealthy, the ſovereigns of which not being in a condition to fortify them, build citadels or caſtles, to ſave expences; as likewiſe to ſave large gariſons to guard and defend them.

In regard to the ſituation of a citadel, if the town lies in an open country, it ought to be built on the higheſt part of the ground, in order to command all the parts of the town, if poſſible; if the town lies near a navigable river or lake, it ſhould be placed near the entrance, to prevent the approach of an enemy with ſhips; and if the place is a ſea-port the

the citadel ſhould be placed near the harbour, ſo as to command it from one end to the other; that it may protect the ſhips lying in it, and ſecure the place againſt any bombardment.

Another conſideration ſhould be had in placing citadels, with reſpect to the town; which is, that the principal ſtreets of the place ſhould be ſeen and lie open to the works of the citadel, in order to fire on them, and diſperſe the mob that might riſe and flock together in time of a ſedition; as likewiſe to prevent the approach of an enemy that way after the town is taken.

An open ſpace, of ſome hundred yards broad, ſhould be left between the works of the citadel and the town, called an *Eſplanade*; which ſerves chiefly to draw up the troops or gariſon, to muſter and exerciſe them there; as likewiſe to prevent any hidden approach that might be carried on from the town againſt the citadel.

The figure of a citadel may be either a ſquare, pentagon, or exagon; but the pentagon is moſt proper, and generally uſed; the exagon being rather too big for that purpoſe, as requiring too great an expence in the building, in proportion to its uſe, or the ad-

advantage arising from it, and the square is thought too inconsiderate for making a sufficient defence.

When a citadel is to be built, either to an old place already fortified, or to a new one; its plan is to be traced by itself on a piece of paper, and upon the same scale as that of the town; then the paper is cut off on that side which is to be next to the town, quite close to the edge of the works, and is laid on that of the town in such a manner, that the ditches and works of the fortification are well flanked and enfiladed by the works of the citadel; and when it is placed according to its proper situation, it is pricked off, and drawn upon the same paper as that of the place.

It happens sometimes that there is a hill, or rising ground, within the fortification of the place, on which the citadel is built; such situations may serve to keep the inhabitants in awe, if it is provided with necessaries, that the garison may defend themselves, till such time that a relief may be sent; but they are of no manner of use against an enemy, who after being in possession of the town may easily reduce the garison in the citadel by famine.

The

The exterior ſides of the citadel are generally about 150 toiſes; but they may be more or leſs, as occaſion requires. Particular care muſt be taken, to fortify the citadel ſtronger than the town, otherwiſe the enemy might attack it firſt, and by the help of which reduce the town; it muſt alſo be obſerved, to make the parts where the citadel joins the town ſufficiently ſtrong, otherwiſe the town and citadel might be attacked together. Moſt citadels that I have ſeen are defective in that reſpect, as we ſhall ſhew hereafter.

There are generally two gates made to a citadel, the one for a communication with the town, and the other with the country; the firſt ſerves for the gariſon to retire into, in caſe of a ſedition, or after the town has capitulated, and the other to receive ſuccour, when the town is taken, or blocked up by the inhabitants.

The citadel takes up generally two ſides of the fortification, and ought to be placed in ſuch a manner, that the ditch of the place may either be defended by the faces of the baſtions, or by thoſe of the ravelins, in as direct a manner as poſſible; otherwiſe the enemy may attack the town in that place,

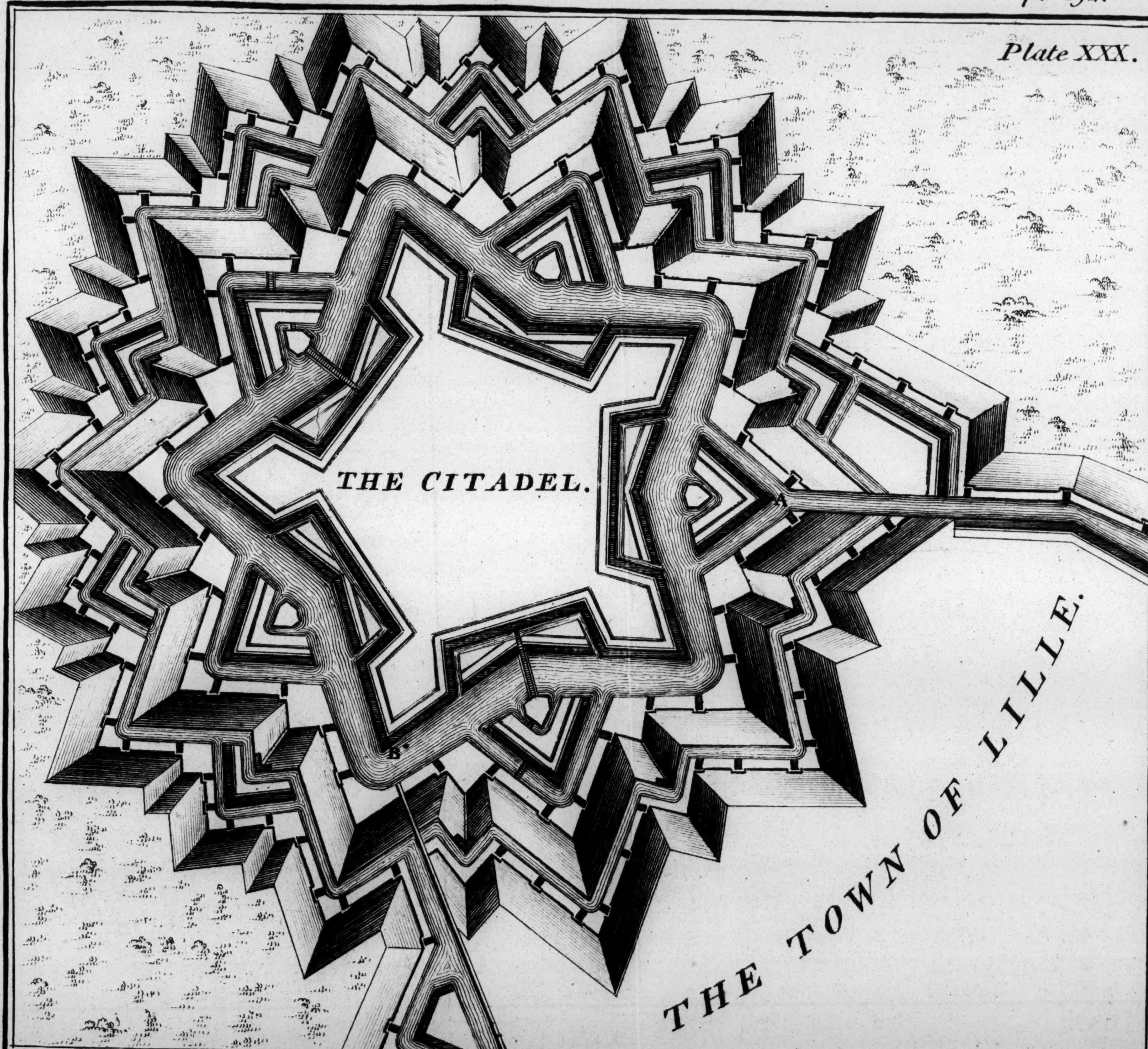
as being the weakeſt; as likewiſe becauſe the ſame attacks may ſerve to reduce both together. The covert-way of the citadel ought to be uninterrupted, ſo that the part next to the town may have a free communication with the other.

In general, a citadel ſhould be conſtructed in ſuch a manner, that an enemy may have no advantage where-ever they make their attacks; and that, if the citadel is attacked firſt, it may coſt them as much time and trouble, as the attacking the town firſt and the citadel afterwards.

There are few citadels, that, in my opinion, are rightly joined to towns; the defence of the ditch is generally ſo oblique and inſignificant, that it appears ſtrange they are not attacked there; that of *Lille* is one
Pl. XXX. of this kind. For the ravelin A cannot defend the oppoſite ditch in the leaſt manner, nor is there any other work that can; ſo that if the town was attacked in that place, the beſiegers would meet with very little obſtacle in the paſſage over this ditch; neither does the baſtion B, defend the oppoſite ditch, which can be done only by the oppoſite covert-way, from which the troops may eaſily be driven by the ricochet batteries.

The

Plate XXX.



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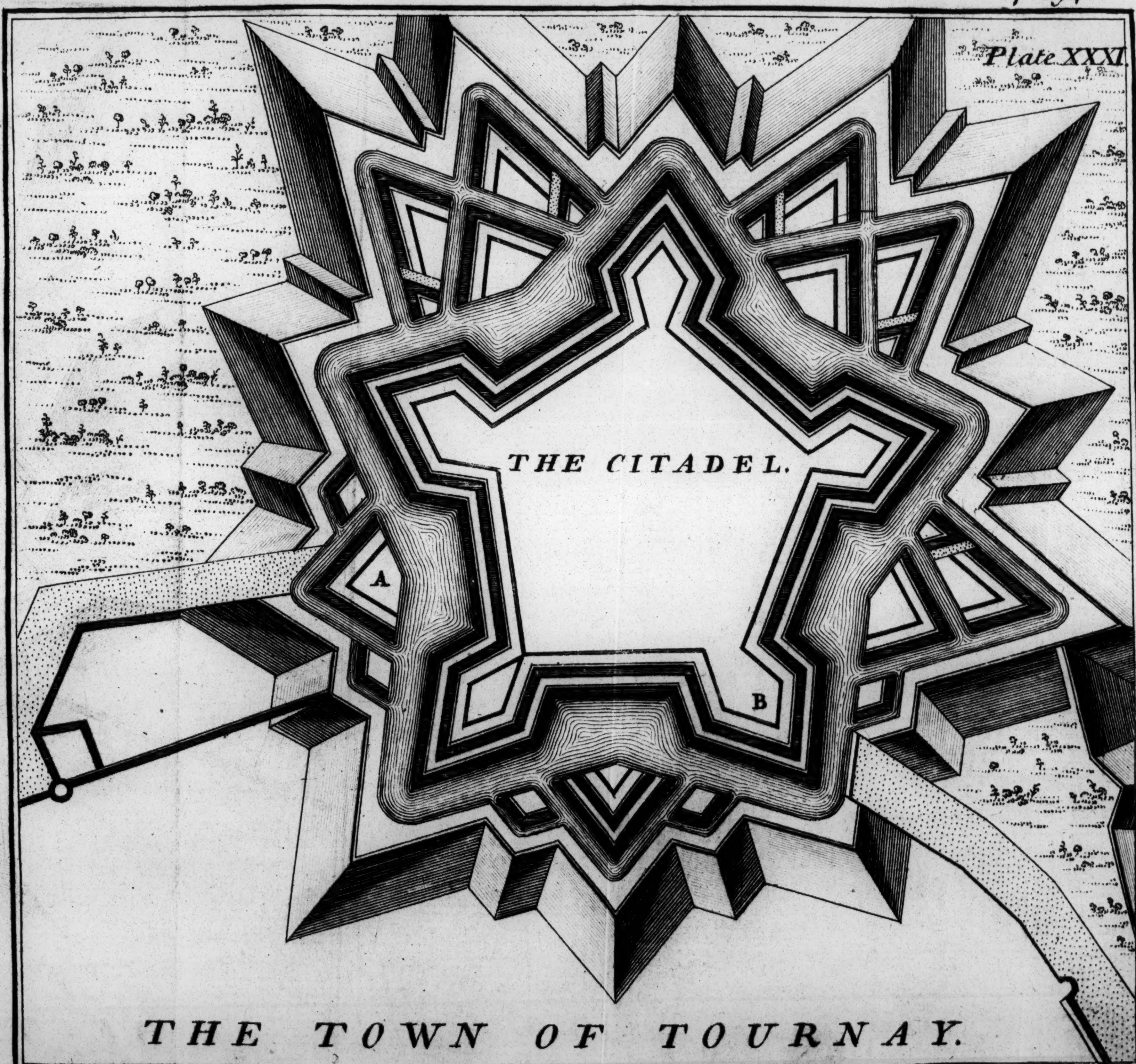
The citadel of *Tournay* is another inſtance of this kind; for neither the ravelin A, nor the baſtion B, can afford any tollerable defence to the oppoſite ditches; and as they are both dry, they are liable to ſerve an enemy for making their trenches in them under cover. This General *Shullenbourg* was ſo ſenſible of, as not to let ſlip the opportunity, when he attacked that place in the late war; for he carried his approaches through that before the baſtion B, and erected a mortar battery there; whereby the prodigious works above and under ground of this citadel, which is eſteemed to be one of the ſtrongeſt in *Europe*, were of no manner of uſe. Pl. XXXI.

It is a matter of ſurpriſe, that an engineer ſhould take ſo much pains in fortifying a place, as Mr. *Maigrigny* did, and put a nation to ſo great expence, without conſidering rightly, whether it may make a defence accordingly, or having a due regard, in making every part equally ſtrong, ſo as not to loſe the advantage propoſed by it, by neglecting ſome, whereby the whole expence is entirely loſt, to the great diſadvantage of a nation.

Laſtly, the citadel of *Arras* is ſtill in a worſe place than either of the foregoing ones; P.XXXII,

for I do not ſee what ſhould prevent an enem
from attacking the town near the citadel i
the place A, ſince the troops being once drive
out of that part of the covert-way, which i
oppoſite to the ditch, by the ricochet batterie
which may ſoon be done, they might then a
eaſily paſs the ditch, as if there was no ci
tadel; by which all the great works abou
the reſt of the town would not be of th
leaſt uſe.

Before we finiſh this ſubject, it will per
haps not be improper to ſay ſomething farthe
of citadels in general: When they are bui
with an intention to keep the inhabitant
who are diſaffected to the government i
awe, methinks, they need not be fortifie
ſo ſtrongly as is cuſtomary; for if the gariſo
can only hold out till ſuch time that ſuccou
may be ſent, it would be ſufficient: fo
which reaſon, if the town is fortified, by cuttin
off two baſtions only, with ſome good retrench
ment; it would anſwer the ends propoſed
well, as the adding another fortification of
great expence, as is moſt commonly pra
tiſed: and as theſe ſupernumerary fortific
tions add but very little ſtrength to the pla
in proportion to the expence, it appears
me, that if a part of that expence were em
ploye



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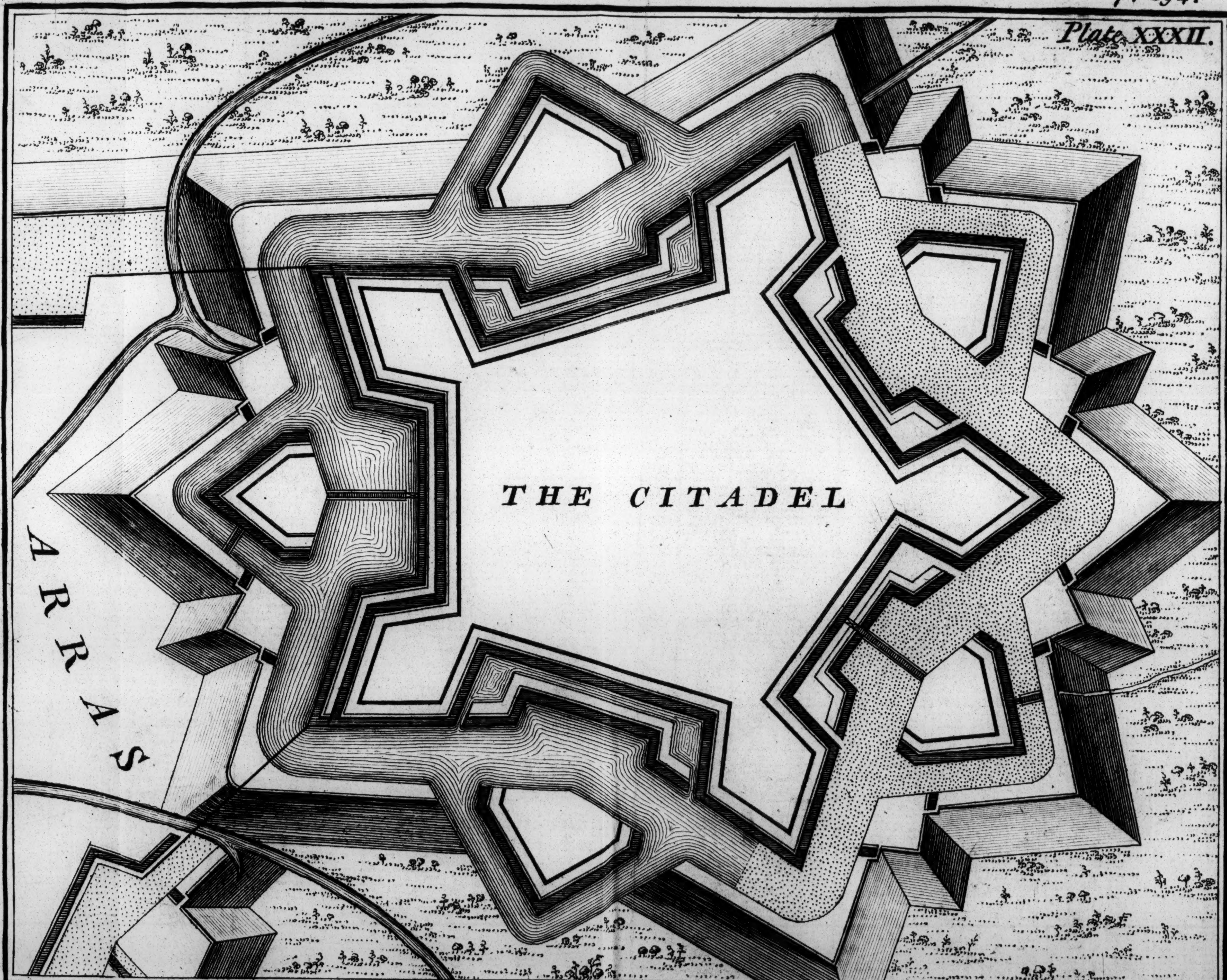
Plate XXXII.
THE CITADEL
ARRAS

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ployed in adding more works to the town itſelf, it would be of more advantage.

The little defence made in the late war, by the citadels of *Lille* and *Tournay*, ſhould, one would think, cure a prince of making theſe ſorts of works ſo expenſive; but there ſeems to be a neceſſity of following the faſhion in fortification as well as in dreſs, to avoid appearing ridiculous.

It may be ſaid, that the want of a good garifon, ammunition, and other neceſſaries was the occaſion of the ſhort defences theſe two citadels made: it may probably be that they were obliged to ſurrender ſomewhat ſooner on this account But if a large town is able to make as long a defence as there is any ammunition and troops to defend it; there ſeems to be not the leaſt occaſion for any more works, which can but little encreaſe the ſtrength of the place.

Beſides it is manifeſt, by what has been ſaid before, that a ſmall place ever ſo well fortified, and provided accordingly, can never make the defence, which a larger may do with leſs works in proportion.

Of Forts and Redouts.

Plate XXXIII. Forts are a kind of ſmall fortifications, built in order to guard ſome paſſes, in a mountainous country, or near cauſeways, rivers, and other ſuch like places. Their figure and bigneſs are various, and depend chiefly on the nature of the ſituation, and importance of the place: Sometimes they are only made triangular, as in the firſt figure, with half baſtions; but this fort is very imperfect, becauſe the faces are not ſeen or defended from any other part. If inſtead of being terminated at the angle, they were directed to a point within about 20 toiſes from it, they would be much better, as being then defended by that length of the rampart, though very obliquely. There ſhould be a ditch of 8 or 10 toiſes about this fort, although we have not markt it in this figure.

Fig. 1.

Fig. 2. Sometimes, they are made as in the ſecond figure, that is triangular as before, but inſtead of making half baſtions at the angles, whole ones are placed in the middle of the ſides. The gorges of theſe baſtions may be from 20 to 24 toiſes, when the ſides are from a 100 to 120, the flanks are perpendicular

dicular to the ſides from 10 to 12 toiſes long, and the capitals from 20 to 24: If the ſides happen to be more or leſs, the parts of the baſtions are likewiſe made more or leſs in proportion; the ditch round this fort may be 10 or 12 toiſes wide.

The ramparts and parapets of theſe ſorts of works are commonly made of turf, and the outſide of the parapet fraiſed; that is, a row of paliſſades are placed in about the middle of the ſlope, in an horizontal manner, the points declining rather a little downwards, that the grenades or fire-works thrown upon them, may roll down into the ditch: and if the ditch is dry, a row of paliſſades ſhould likewiſe be placed in the middle of it, to prevent the enemy from paſſing over it unperceived, and to ſecure the fort from any ſurpriſe.

Forts are moſt commonly made ſquare, as in the third figure; at leaſt, when the paſs they are to guard, is of any conſequence, or the place may eaſily be approached; the ſides of this ſquare are a 100 toiſes, the perpendicular 10, and the faces 25; the ditch about this fort may be from 10 to 12 toiſes; the parapet is to be made of turf, and fraiſed, and the ditch paliſſaded when dry. There may Fig. 3.

be made a covert-way about this fort, or elſe a row of paliſſades might be placed on the outſide of the ditch.

They are often made of various figures, regular or irregular, ſometimes in the form of a ſemi-circle, eſpecially when they are ſituated near a river, ſea, or at the entrance of a harbour; by which figure, they are able to fire at the ſhips on all ſides of it; at others with a long ſide, and ſeveral ſmall ones without any baſtions; this ſhould however not be done, but when they cannot be approached, without much time and difficulty: for it is not ſuppoſed that any fort can hold out long, againſt a ſuperior force provided with artillery; their intent is only to prevent parties of an enemy to paſs that way, and to ſtop them for ſome time till they may be ſuccoured.

When a fort is to be built in the neck of land, formed by the confluence of two rivers, or in the windings of a river, in order to prevent an enemy from tranſporting any thing by water, or to prevent the paſſing of their ſhips that way; the figure of the fort muſt be adapted to the ſituation, in ſuch a manner, that there may be no place for landing troops, but what can be diſcovered by the fire

fire of ſome work or other, and the ſide next to the land, ſhould always be better fortified than the other parts near the river; as being more liable to be attacked.

The fourth figure, repreſents ſuch a fort; three ſides of which are a 100 toiſes each, and the fourth but 50, as ſuppoſing the ground to be narrow in that place; the perpendiculars to the greateſt ſides are 14, and the faces 30; the perpendicular to the other 10, and the faces 15: the capitals of the ravelins 25; the great ditch 12; that before the ravelin 8, and the covert-way 4 or 5. The narrow front towards the land is covered by a horn-work, whoſe front is at the diſtance of 36 toiſes from that of the fort, and 90 long, the perpendicular 12, faces 25, and the branches 10 toiſes broad at their extremities; the capital of the ravelin before this work is 22 toiſes, the ditch before the horn-work 8, and that before the ravelin 6 or 7. Fig. 4.

We ſhall add another example of this kind, ſuch as is repreſented by the fifth figure; the land is ſuppoſed to open gradually; for which reaſon three ſides are a 100 toiſes each, and the fourth 160; the perpendiculars to the ſhorteſt 12, and the faces 30; Fig. 5.

that to the greateſt 20, and the faces 45; the ditch before the three ſhort ſides is 12, and 18 before the greateſt. The capital of the ravelin is 46 toiſes, its ditch 10; the faces of the lunettes are at right angles to thoſe of the ravelin, and fall within 16 toiſes from the ſaliant angle; theſe faces are 25 toiſes long, and the others are perpendicular to thoſe of the baſtions; the narrow part of the bonnet is 10 toiſes, and the faces are perpendicular to thoſe of the lunettes, or parallel to thoſe of the ravelin; the ditches before the lunettes and bonnet are 8 toiſes, and the covert-way 4.

There are generally great faults committed in the conſtructions of forts near the ſea, or navigable rivers, for want of rightly conſidering all the different circumſtances attending theſe ſort of works, and without which it is impoſſible that a work will ever anſwer the intents and purpoſes, for which it was built. For inſtance, if a battery or fort, built near the water where ſhips may approach, has its parapet not of a ſufficient height; thoſe behind them may be fired upon, from the round top of the maſt, by which the gunners are obliged to abandon their guns, to ſave themſelves by flight; and

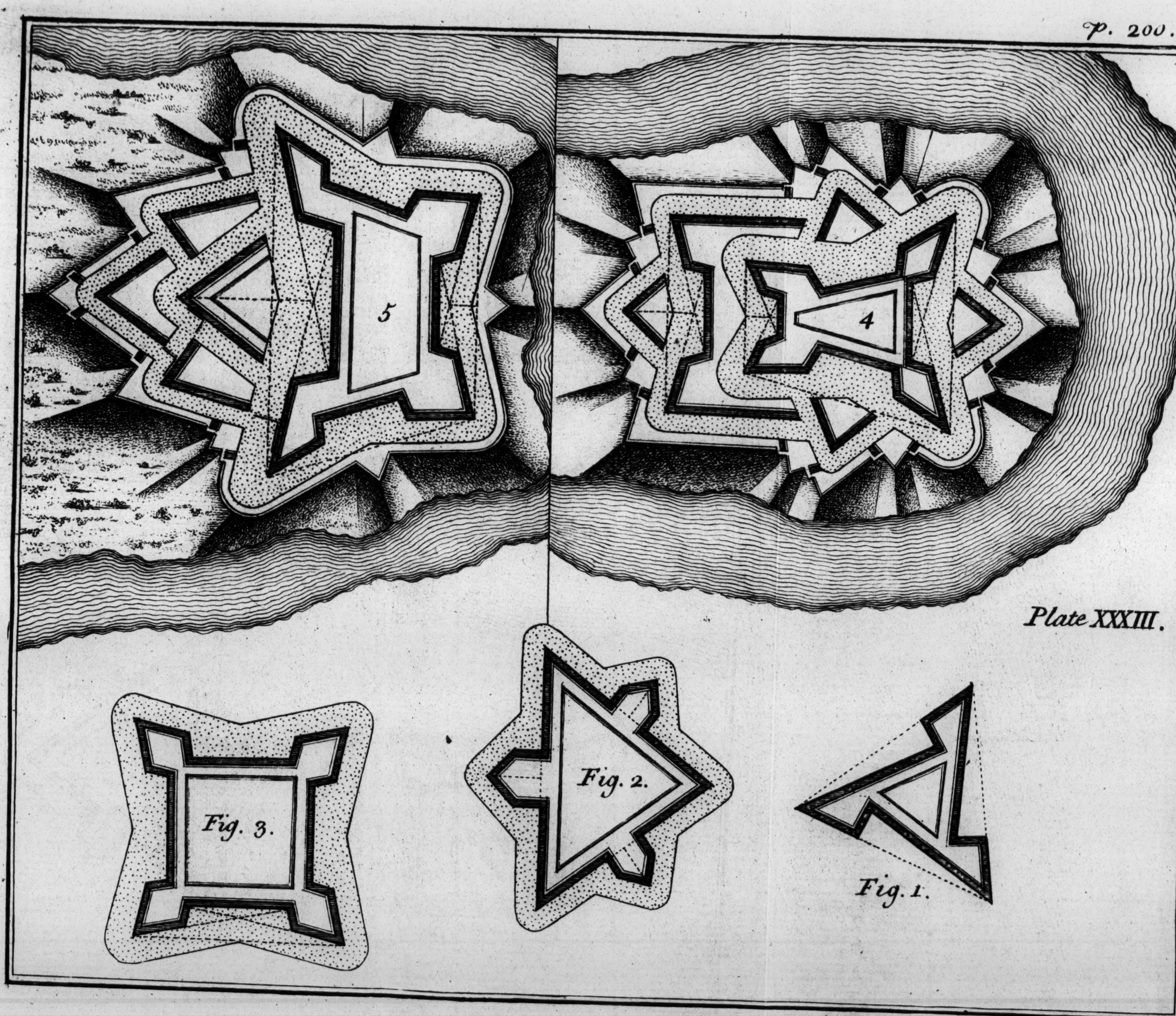
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Plate XXXIII.
Fig. 3.
Fig. 2.
Fig. 1.

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and ſo theſe forts or batteries become of little or no uſe.

This was the caſe at *Portobello*, when attacked by admiral *Vernon*; for the forts and batteries, which were deſigned to defend the harbour, had been made ſo low, that the ſhips could come quite cloſe to them, and the troops in them, were ſoon obliged to take to their heels and run away.

There is generally another fault committed, which is, that if theſe forts or batteries are left open behind, or are very little fortified towards the land; the enemy may land men in the dark, and ſurpriſe them, by which the guns placed in them, become not only uſeleſs to the place, but ſerve rather to deſtroy it.

At *Carthagena*, the *Spaniards* had a faſcine battery on the other ſide of the entrance into the harbour, oppoſite to the camp, by which they prevented ſhips from going in; ſailors were ſent to take it, which was ſoon performed, but being ſatisfied with driving only the *Spaniards* from it, they were obliged to take it a ſecond time to nail up the guns.

The ſame thing happened laſt year at *Cape Breton*, where the *French* had a battery of 15 large pieces of canon; which the *Engliſh* ſurpriſed in the dark, and turned the canon againſt

againſt the place, whereby they became ſoon maſters of it. Many examples might be cited of this kind, to ſhew, that the want of judgment in building theſe forts, has proved a detriment, inſtead of an advantage, to the places which they ſhould have defended.

To prevent the inconveniency of being ſeen behind the parapet, it will be neceſſary to make them 9 or 10 feet high; and to cover the batteries overhead, which may be done, by making an arch over every piece left open behind to let out the ſmoak; but if this ſhould be thought too expenſive, they might be covered with planks, like ſhads, and to prevent the wood being ſet a fire, they may be covered with earth or dung about a foot and a half thick: for if it is but ſtrong enough to reſiſt muſket ſhot, it is ſufficient

And to prevent a fort or battery being ſurpriſed, they ſhould be fortified all round with a good rampart and ditch at leaſt, or with an addition of outworks, if the place is of any importance; the rampart muſt be fraiſed with paliſſades, if it is made with turf, and the ditch ſhould have a row of paliſſades planted in the middle of it, in caſe it is dry; which will prevent an enemy approaching unperceived.

It

It has been the cuſtom in latter times, for ſhips to approach forts and deſtroy them without any concern, as knowing too well the little danger they expoſe themſelves to; and this has been occaſioned by their bad conſtructions; whereas, if they were made as they ſhould be, it would not be impoſſible to ſink every ſhip that ſhould dare venture to come near them. The reaſon of this is plain, if we conſider the uncertainty there is to fire from a ſhip, which is in a continual motion, and that a battery, covered with a good parapet, may watch the opportunity, when the ſhip comes near and oppoſite to it, fire all the guns at once, pointing nearly at the ſame place a little above the water, which will hardly fail of deſtroying it.

On the contrary, if the guns of the ſhip hit the battery by chance, they can do it but little or no damage, when the parapet is well made.

There are ſome who are of opinion, that ſhips will always be able to deſtroy a fort, on account that they have more guns within a leſs compaſs than any battery on land can have; and if the contrary happens, it is more owing to the cowardiſe of the commander, than to any thing elſe; but this is a wrong notion,

notion, as we ſhall make appear. For ſuppoſe a firſt rate man of war, which has three decks, and therefore may have perhaps four, five, or ſix guns to one; the chance of hitting the battery on account of the ſhip's motion, is not above three to one; and when the ſhot ſtrikes the parapet, it can do it but very little damage, excepting it ſhould hit a gun by chance, which it would diſmount; but this is not ſo eaſily done, conſidering the ſmallneſs of the gun with regard to their intervals; it is certain not one gun in 30 will hit; whereas the battery may watch the opportunity, ſo as when the ſhip comes near and oppoſite, to make a general diſcharge with all the guns; where there will be not one that miſſes, and every ſhot will make its hole into the ſhip, and deſtroy all things that is in its way. From whence it may be concluded with juſtice, that ſhips are never able to deſtroy any fort, when it is conſtructed in the manner it ſhould be.

If the nature of the ground is ſo as to admit of making two batteries, one above the other, it ſhould not be neglected; the one nearly a level with the ſurface of the water, to fire in a horizontal direction, and the other to plunge into the ſhips; ſo that if the troops placed

placed on the lower, being well protected in the front by a high parapet, and covered above with arches or planks, it will not be in the power of ſhips to deſtroy them, as has been done heretofore.

If there is any flates of ſand or rocks, near or within the entrance of a harbour, it will be very proper to build ſome tower or fort there, of ſeveral ſtories, well arched, ſo as to be bomb proof, in order to place ſeveral ranges of guns in them; but as the ſmoak might be troubleſome in the lower ſtories, I would make it open in the middle, that is, I would make two concentric walls, ſo that the arches of the roofs of the lower ſtories might be quite open behind; and in caſe the enemy ſhould throw ſhells, and hit the upper battery, it might be ſo contrived, that the ſhells may roll down the opening in the middle, without doing any damage.

Fort St. *Louis*, in the road before the harbour of *Toulon*, is ſuch a work, of a round form, built upon a rock within the water; and the towers, called *Egillette* and *Vignette*, are places of the ſame nature in a ſquare form, built upon the necks of land on both ſides of the mouth of the road.

It

It is the cuſtom of ſome modern engineers, when they build any fort or battery near the ſea or navigable rivers, to make a parapet of three feet high only, in order to fire the guns en barbet; the reaſon they give for this practice is, that they may point the guns which way they pleaſe, either down the river, to prevent the ſhips from approaching, deſtroy them when they are oppoſite, or firing after them in caſe they ſhould paſs. However ſpecious theſe reaſons appear at firſt, yet when it is rightly conſidered, it will be found that this practice is not ſo advantageous as they imagine. For if they fire at the ſhips when they are yet far off, they can do them but very little damage; and the advantage gained thereby, will not by far be equivalent to the danger they will themſelves be expoſed to, when the ſhips come near; ſince one broad ſide, together with the fire of the ſmall arms, will be ſufficient to kill or diſable all thoſe which are on the battery. On the contrary, if the batteries are well covered in the front by a good parapet, and above by planks, or only ſail-cloth, and made in ſuch a manner, as that ſome guns may be directed down the river, and others upwards; this battery will have all the advantage which they can pre-

tend

tend to gain by their practice, and none of its disadvantages.

Another method is also used, much more defective than this, which is, to build the parapets of brick or stone only, without any earth behind it; for as soon as the ships come once within reach of the fort or batteries, they may easily destroy this parapet, and the pieces of stones or bricks will be more dangerous to the defenders than the enemy's shot itself. And it has been found by experience, that nothing disheartens troops placed behind a wall so much, as the pieces of stone flying about their ears; and therefore, such a practice should be avoided as much as possible; besides the adding 10 or 12 feet of earth only to the wall, will be but a trifling expence, and yet sufficient to protect the troops from this danger.

Having explained the methods of the most celebrated authors, and carefully examined their constructions, to the best of our judgment, without the least partiality, we hope to have done all that is necessary to compleat the elementary part of fortification; which being well understood, will, I hope, be suf-

ficient for underſtanding the ſubject; and to leave nothing that might any ways contribute to the reader's ſatisfaction, we ſhall ſubjoin the following explanation of the principal terms uſed in fortification, by way of a dictionary, to which recourſe may be had, when there is any occaſion for it.

An Explanation of the principal terms uſed in Fortification, digeſted in an alphabetical manner.

A.

ANGLE of the center of a polygon, is formed by two radii drawn to the extremities of the ſame ſide.

Angle of the polygon, is made by the concourſe of two adjacent ſides of a polygon.

Angle of the flank, is made by the curtain and the flank.

Angle of the ſhoulder, is made by the face and flank of the baſtion.

Approaches, are a kind of roads or paſſages ſunk in the ground by the beſiegers, whereby they approach the place under cover of the fire from the gariſon.

Arrow, is a work placed at the ſaliant angles of the glacis, and conſiſts of two parapets, each 40 toiſes long; this work has a communication with the covert-way of about 24 or 30 feet broad, called caponier, and a ditch before it of 5 or 6 toiſes.

Aſſault, is a ſudden and violent attack, made uncovered, on the part of the rampart where a breach has been made.

Attack, is the manner and diſpoſition made by an army or a great party, to drive out an enemy of a fortified place, or of any kind of ſtrong ſituation.

B.

Barbet, when the parapet of a work is but three feet high, or the breaſt-work of a battery is only of that height, that the guns may fire over it without being obliged to make embraſures, it is ſaid that the guns fire in barbet.

Baſtion, is a part of the inner incloſure of a fortification; making an angle towards the field, and conſiſts of two faces, two flanks, and an opening towards the center of the place called the gorge.

A baſtion is ſaid to be full, when the level ground within is even with the rampart, that is, when the inſide is quite level, the parapet being only more elevated than the reſt.

And a baſtion is ſaid to be empty, when the level ground within is much lower than the rampart, or that part next to the parapet, where

where the troops are placed to defend the baſtion.

Banquette, is a kind of ſtep made on the rampart of a work near the parapet, for the troops to ſtand upon in order to fire over the parapet; it is generally three feet high and as many broad, and $4\frac{1}{2}$ feet lower than the parapet.

Battery, is a work made to place guns or mortars on it; it conſiſts of an epaulement or breaſt-work of about 8 feet high and 18 or 20 thick; when it is made for guns, openings or embraſures are made in it, for the guns to fire through them.

Berm, is a little ſpace or path of 6 or 8 feet broad, between the ditch and the parapet, when it is only made of turf, to prevent the earth from rolling into the ditch, and ſerves likewiſe to paſs and repaſs.

Blind, is two ſticks faſtened together by two ſpars of about 4 feet aſunder, they ſerve to cover the ſaps, or to keep up the earth on the ſides by placing faſcines behind them.

Blockade, is the encompaſſing a fortified place with an army, ſo that it muſt either be ſtarved or ſurrender.

Body of the place, although the buildings in a fortified place are properly ſaid to be the

P 2 body

body of the place, yet the inclosure round them is generally understood by it: for it is said, to construct the body of the place, which means no more than to fortify or inclose the place with bastions and curtains.

Bombs, is the name of the ships which carry mortars.

Bombardment, is when a great number of shells are thrown into a place, to ruin and destroy the buildings.

Bonnet, is a sort of work placed before the saliant angle of the ravelin to cover it.

Barracks, are those piles of buildings made on purpose to lodge the soldiers in them.

Breach, is an opening made in a wall or rampart, with cannon or mines, sufficiently wide for a body of troops to enter the works, and drive the besieged out of it.

C.

Capital of a work, is an imaginary line which divides that work into two equal and similar parts.

Capitulation, is the agreement made by the besieged with the besiegers, on what conditions the place is to surrender.

Camp,

Camp, is the ſpot of ground occupied by an army for a night or more, and where they pitch their tents.

Caponier, is a paſſage made from one work to another, of 10 or 12 feet wide, covered on each ſide by a parapet, terminating in a ſlope or glacis.

Thus when the ditch is dry, the paſſage from the curtain to the ravelin, or that from the covert-way to the arrow's or detached redouts, are called caponiers.

There are often ſingle parapets raiſed at the entrance of the ditch before the ravelin, to place ſmall cannons and men behind them, to diſpute the paſſage over that ditch; which are likewiſe called caponiers.

Cavalier, is a work raiſed generally within the body of the place, ten or twelve feet higher than the reſt of the works. Their moſt common ſituation is within the baſtion, and made much in the ſame form; ſometimes they are alſo placed in their gorges or on the middle of the curtain; they are then made in the form of a horſe ſhoe, only ſomewhat flatter.

The uſe of cavaliers is, to command all the adjacent works and country about it; they are ſeldom or never made but when there

is a hill or rising ground which overlooks some of the works.

Casemate, is a work made under the rampart, like a cellar or cave with loop-holes, to place guns in it.

Chamade; when the governor of a place besieged wants to capitulate, then the drums beat on the rampart next to the attack, which is called chamade.

Cheveaux de Frize, large joists or beams stuck full of wooden pins armed with iron, to stop breaches, or to secure the passages of a camp, against the enemy's cavalry.

Covert-way, is a space five or six toises broad, going quite round the works of a fortification, and is adjoining to the counterscarp of the ditches, covered by a parapet $7\frac{1}{2}$ feet high, terminating in an easy slope towards the field, at a distance of 20 toises.

Center of the bastion, is the point within where the two adjacent curtains produced intersect each other.

Citadel, is a kind of fort or small fortification of four, five, or six sides, joined to towns, when the inhabitants are suspected to be disaffected to the government.

Command, when a hill or rising ground overlooks any work of a fortification, and

is

is within the reach of cannon ſhot; this hill is ſaid to command that work.

Chamber, is that place of a mine where the powder is lodged.

Countermines, are the mines made within the fortification, either at the ſame time the place is fortified, or afterwards in the time of a ſiege.

Counterſcarp, is the outſide of a ditch, oppoſite to the parapet of the work behind the ditch; it is often ſaid, that the beſiegers have carried their lodgments upon the counterſcarp, which means, they are lodged on the covert-way.

Counterguard, is a work placed before the baſtions to cover the oppoſite flanks from being ſeen from the covert-way; they are likewiſe made before the ravelins.

When they are placed before the baſtions, they are eſteemed to be of a very good defence.

Crown-work, is a kind of work not unlike a crown; it has two fronts and two branches; the fronts are compoſed of two half baſtions and one whole one; they are made before the curtain or the baſtion, and generally ſerve to incloſe ſome buildings which cannot be brought within the body of the

place, or to cover the town gates, or elſe to occupy a ſpot of ground, which might be advantageous to an enemy.

Cordon, is a round projection made of ſtone, in a ſemi-circular form, whoſe diameter is about 8 inches, which reigns quite round the wall, within four feet from the upper part.

Curtain, is the part of the body of the place, which joins the flank of one baſtion to that of the next.

Cuvette, or rather *Cunette*, is a ſmall ditch of 10 or 12 feet broad, made in the middle of a large dry ditch, ſerving as a retrenchment to defend the ditch, or elſe to let water in it, when it can be had in the time of a ſiege.

Counterforts, or *Buttreſſes*, are ſolids of maſonry, built behind walls, and joined to them, at 18 feet diſtance from center to center, in order to ſtrengthen it, eſpecially when it ſuſtains a rampart or terras.

Communication, is a paſſage from one work to another, covered by a parapet on each ſide, ſee *caponiers*.

D.

D.

Decagon, is a polygon or fortification of ten ſides.

Demi-lune, or *Ravelin*, is a work placed before the curtain to cover it, and prevent the flanks from being diſcovered ſideways; it is made of two faces meeting in an outward angle.

Detached baſtion, is that which is ſeparated from the reſt of the body of the place, and is made in the ſame manner as thoſe which are joined to the body. Counterguards with flanks are alſo called detached baſtions, as in M. *Vauban*'s ſecond and third methods.

Detached redout, is a work made at ſome diſtance from the covert-way, much in the ſame manner as a ravelin with flanks.

Ditch, is a large deep trench made round each work, and the earth dug out of it, ſerves to raiſe the rampart and parapet.

Dodecagon, is a figure or fortification of twelve ſides.

E.

Escarp, is properly any thing high and steep, and is used in fortification to express the outside of the rampart of any work next to the ditch, as being high and steep.

Embrasures, are openings made in the flanks of a fortification, or in the breast-work of a battery, of about $2\frac{1}{2}$ feet within, 8 or 9 without, and 3 from the bottom, for the guns to enter partly, and to fire through.

Enfilade, a work is said to be enfiladed, when a gun may fire into it, so that the shot may go all along the inside of the parapet.

Epaulement, is a kind of breast-work to cover the troops in front and sometimes in flank.

In a siege, the besiegers raise generally an epaulement of 9 or 10 feet high, near the entrance of the approaches to cover the cavalry, which is placed there to support the guard of the trenches.

Esplanade, is an open space between the citadel and town, to prevent an enemy from making approaches under cover after he is master of the place.

En-

Enneagon, is a nine-ſided figure or fortification.

Eptagon, a ſeven-ſided one.

Exagon, a ſix-ſided one.

Exterior ſide of a fortification, is the diſtance or imaginary line drawn from one point of the baſtion to that of the next.

F.

Faces, of the baſtion, are the two ſides which meet in an angle projecting towards the field.

Faces, of any work, are thoſe parts where the rampart is made, making an angle pointing outwards.

Faſcine, a kind of faggot made of branches tied in two or more places of about 6 or 8 inches diameter.

They ſerve to keep up the earth in trenches, as likewiſe in batteries, inſtead of ſtone or brick walls.

When they are uſed in raiſing batteries, they are generally 16 feet long; and are then called *Sauciſſons*.

Fauſſ-bray, is a low rampart going quite round the body of the place, their height is about 3 feet at moſt above the level ground; and

and its parapet is about 4 or 5 toiſes diſtance from that of the body of the place.

Theſe works have been entirely rejected by the modern engineers, excepting M. *Vauban*, who makes them only before the curtains, and then they are called tenailles.

Flank, in general, is a part of a work, which defends another work along the outſide of its parapet.

Flank of the baſtion, is the part between the face and curtain; the flank of one baſtion ſerves to defend the ditch before the curtain, and face of the oppoſite baſtion.

Flank (concave) is that which is made in an arc of a circle.

Flank (retired) is that which is made behind the line, which joins the extremity of the face and the curtain, towards the capital of the baſtion. M. *Vauban* makes his 5 toiſes from that line, others more or leſs, as it happens.

Flanking, is the ſame thing in fortification as defending.

Flank (direct or graſing) is that which is perpendicular to the oppoſite face produced; and oblique or fiſhant, when it makes an acute angle with that face.

Flank

Flank (ſecond) when the face of a baſtion produced, does not meet the curtain at its extremity, but in ſome other point; then that part of the curtain between that point and the flank, is called ſecond flank. The modern engineers have rejected this way of fortifying.

Fort, is a ſmall fortification, made in a paſs, near a river, or at ſome diſtance from a fortified town; to guard the paſs, or to prevent the approach of ſhips, or an enemy by land.

Fortification, is a general name for any work made to oppoſe a ſmall number of troops againſt a greater.

Fourneau, is the place of a mine, where the powder is lodged, and is the ſame thing as the chamber of a mine.

Fougaſs, is a ſmall mine, from 6 to 8 feet under ground; they are generally placed under the glacis or dry ditches.

Fraiſe, a kind of ſtakes or paliſſades placed horizontally on the outward ſlope of a rampart made of turf, to prevent the work being taken by ſurpriſe.

When an army retrenches itſelf, they often fraiſe the parapets of their retrenchments in the parts moſt expoſed of being attacked.

Fuſe,

Fuſe, is the piece of wood drove into grenades or ſhells, being hollow and filled with mealed powder, by which the grenade or ſhell is fired.

G.

Gabion, is a cylindric baſket open at both ends, of about 3 feet wide, and as much in height; they ſerve in ſieges to carry on the approaches under cover, when they come pretty near the fortification.

Gabion, (ſtuft) is made in the ſame manner as the former, they are only filled with all ſorts of branches and ſmall wood, and are 5 or 6 feet long; they ſerve to roll before the workmen in the trenches, to cover them in front againſt muſket-ſhot.

Gallery, is the paſſage made under ground leading to the mines; they are from 4 $\frac{1}{2}$ to 5 feet high, and about 4 feet broad; the earth above is ſupported by wooden frames with boards over them.

Gariſon, a body of troops compoſed of horſe and foot, placed in a fortification to guard it in time of peace, and to defend it in time of war, in caſe an enemy ſhould attack it.

Glacis,

Glacis, is that part of a fortification beyond the covert-way, to which it ſerves as a parapet, and terminates towards the field in an eaſy ſlope at about 20 toiſes diſtance.

Gorge, of a baſtion, is the interval between the extremity of one flank to that of the other.

Gorge, of any work, is that part next to the body of the place, where there is no rampart or parapet; that is, at the counterſcarp of the ditch.

Grenade, is an iron ball of about 3 inches diameter hollow within; which is filled with powder, to be thrown by the grenadiers amongſt the enemy in an attack, after having ſet fire to the fuſee that it may burſt.

H.

Hornwork, is compoſed of a front and two branches; the front is made into two half baſtions and a curtain: this work is of the nature of a crown-work, only ſmaller and ſerves for the ſame purpoſes.

Half-moon; ſee *Demilune*.

Hurtor, is a piece of timber about 6 inches ſquare, placed before the wheels of a carriage, againſt the parapet of a battery, to prevent the wheels from doing damage to the parapet.

I.

Insult, a work is said to be insulted, when it is attacked suddenly and openly.

Investing a place, is to surround it with troops, so as to prevent any thing to enter the place, or to be carried out of it: it is the first operation of a siege.

Interior side of a fortification, is the imaginary line drawn from the center of one bastion to that of the next, or rather the curtain produced to the centers of the bastions.

L.

Line of defence, is the distance between the saliant angle of the bastion, and the opposite flank; that is, it is the face produced to the flank.

Line of circumvallation, is the work or retrenchment made about an army which besieges a place, to secure it against any insult from without; it is made of a parapet with a ditch before it, and at every 120 toises or thereabout, the parapet projects outwards in an angle; this projection is called a *Redan*, and serves to flank or defend the other parts.

Line of countervallation, is the work made by an army which beſieges a place between their camp and the town, to cover it againſt any enterpriſe of the gariſon; it is made much after the ſame manner as the line of circumvallation, only in a contrary diſpoſition.

Line, is alſo the name of the works made by an army from one town or ſtrong poſt to another, behind which it is encamped, to guard a part of the country.

Line of counter-approach, is a kind of trench made by the gariſon when beſieged, going from the covert-way in a right line, ſo as part of the enemy's approaches may be enfiladed from thence.

Lodgment, is the work made by the beſiegers in ſome parts of a fortification, after the beſieged have been drove out, to maintain it.

Loop-holes, are ſquare or oblong holes made in the wall, to fire through with muſkets.

Lunettes, are works made on both ſides of a ravelin; one of their faces is perpendicular to half or two thirds of the faces of the ravelin, and the other nearly ſo to thoſe of the baſtions.

Lunettes, are alſo works made beyond the ſecond ditch, oppoſite to the places of arms; they differ from the ravelins only in their ſituation.

M.

Mantlet, is a kind of moving parapet made of ſtrong planks, about 4 feet long and 3 high, mounted upon two wheels, with a long pole fixed to it; they ſerve to cover the ſappers in the front againſt muſket-ſhot.

Mine, is a kind of lodgment made under ground to place powder in it, which is ſet on fire, in order to blow up the works above it; the difference between mines and countermines is, that the firſt are made by the beſiegers, and the latter by the beſieged.

O.

Octogon, is an eight-ſided figure of fortification.

Ondecagon, an eleven-ſided one.

Orillon, is a part of the baſtion near the ſhoulder, which ſerves to cover the retired flank from being ſeen obliquely.

Orgues, many harquebuſſes linked together, or divers muſket barrels laid in a row, ſo that they may be diſcharged either all at once or ſeparately; alſo long and thick pieces of wood with iron plates at the end, hung over a gate, to ſtop it up inſtead of a portcullice.

P.

Paliſſades, are a kind of ſtakes made of ſtrong ſplit wood of about 9 feet long, fixed 3 feet deep in the ground in rows about 6 inches aſunder; they are placed in the covert-way at 3 feet from, and parallel to the parapet or ridge of the glacis, to ſecure it from being ſurpriſed.

Parapet, is a part of the rampart of a work, of 18 or 20 feet broad, and raiſed 6 or 7 feet above the reſt of the rampart; it ſerves to cover the troops, placed there to defend the work, againſt the fire of the enemy.

Parallels, or places of arms, are deep trenches 15 or 18 feet wide, joining the ſeveral attacks together; they ſerve to place the guard of the trenches in, to be at hand to ſupport the workmen when attacked.

There

There are generally three in an attack; the first is about 300 toises from the covert-way, the second 160, and the third near or on the glacis; they were first invented or used by M. *Vauban*.

Petard, is a kind of a brass pot fixed upon a strong square plank, which has an iron hook to fix it against a gate or palissades; this pot is filled with powder, which when fired, breaks every thing about it, and thereby makes an opening for an enemy to enter the place.

Port-cullice, is a falling gate or door like a harrow, hung over the gates of fortified places, and let down to keep out the enemy.

Place, is commonly used in fortification, instead of a fortified town.

Place of arms, of the covert-way, is a part of it, opposite to the re-entring angle of the counterscarp, projecting outwards in an angle.

Places of arms, in an attack; see parallels.

Plat-form, is a floor made of strong planks, laid upon joists, on a battery, to place the guns or mortars upon, in order to prevent the wheels or mortar-bed from sinking in the ground.

R.

Rampart, is an elevation of earth raiſed along the faces of any work, of 10 or 15 feet high, to cover the inner part of that work againſt the fire of an enemy.

Rams-horns, are a kind of low work made in the ditch of a circular arc; they were invented by M. *Belidor*, and ſerve inſtead of tenailles.

Re-entring angle, is that which turns its point towards the center of the place.

Ravelin. See demi-lune.

Redans. See line of circumvallation.

Redout, is a kind of work placed beyond the glacis, of various forms.

Redout, is alſo the name of a ſmall work made in a ravelin, of the ſame form.

Redout, is likewiſe a ſquare work without any baſtions, placed at ſome diſtance from a fortification, to guard a paſs, or to prevent an enemy from approaching that way.

Revetement, is a ſtrong wall built on the outſide of the rampart and parapet, to ſupport the earth, and prevent its rolling into the ditch.

Ricochet, when guns are loaded with ſmall charges, and are elevated from 10 to 12 degrees,

grees, ſo as to fire over the parapet, and the ſhot rolls along the oppoſite rampart; it is called ricochet firing, and the batteries are likewiſe called ricochet batteries.

S.

Sally, is when a party of a gariſon goes out privately, and falls ſuddenly on the beſiegers in their trenches, endeavouring to drive them out and deſtroy their works.

Saliant angle, is that whoſe point turns from the center of the place.

Second ditch, is that which is made on the outſide of the glacis, when the ground is low and water to be had.

Second covert-way, is that which is made beyond the ſecond ditch.

Sap, is a trench, or an approach made under cover of 10 or 12 feet broad, when the beſiegers come near the place, and their fire grows ſo dangerous, as not to be approached uncovered.

Siege, is when an army approaches a fortified place, and ſurrounds it on all ſides, endeavouring to oblige the gariſon to ſurrender, either by deſtroying the works of the fortification, or thoſe which defend them.

Sau-

Saucisson, is a long pipe or bag, made of cloth or leather, of about an inch and a half diameter, filled with powder, going from the chamber of a mine to the entrance of the gallery; it serves to give fire to the mine.

Saucisson, is likewise a fascine much longer than the common ones; they serve to raise batteries, and to repair breaches.

T.

Talud, or slope, is made to the works of a fortification, both on the outside and inside, to prevent the earth from rolling down.

Traverse, is a parapet made cross the covert-way, opposite to the saliant angles of the works and near the places of arms, to prevent enfilades; they are 18 feet thick, and as high as the ridge of the glacis. There are also traverses made in the caponiers, but then they are called *tambour*.

Traverses, are likewise made within other works, when there are any hills or rising grounds, which may see the inside of these works.

Tenailles,

Tenailles, are low works made in the ditch before the curtains; there are three ſorts, *viz.* The firſt are the faces of the baſtions produced, till they meet, but much lower; the ſecond have faces, flanks, and a curtain; and the third, have only faces and flanks.

Tenaillons, are works made on each ſide of the ravelin, much like the lunettes; they differ, in that one of the faces of a tenaillon is in the direction of the face of the ravelin; whereas that of the lunette is perpendicular to it.

Tower baſtions, ſmall towers made in the form of baſtions by M. *Vauban*, in his ſecond and third method; with rooms or cellars underneath, to place men and guns in them.

The END.